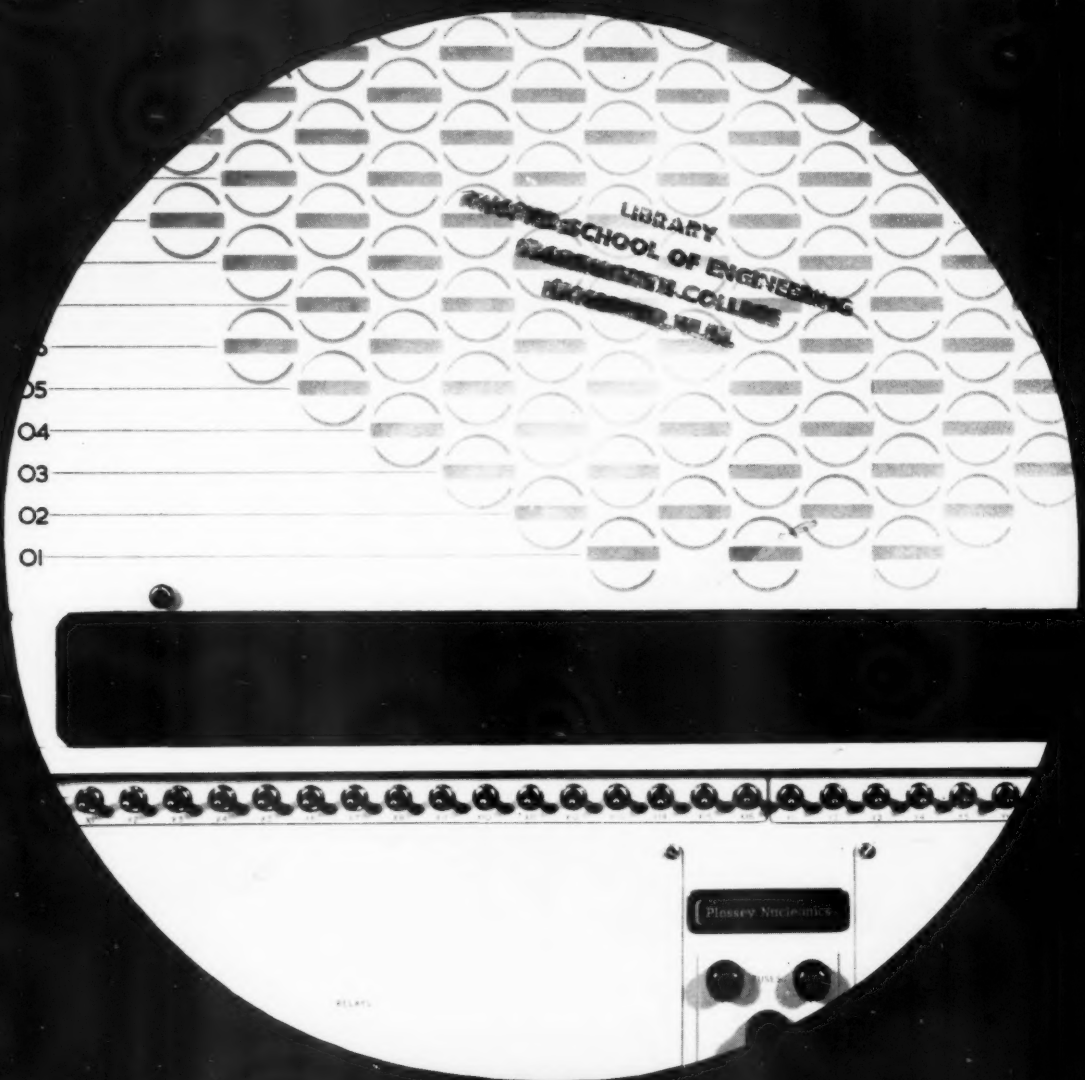
A ROWSE MUIR PUBLICATION

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION



Eurochemic design problems

Burst slug detection on the AGR

Engineering, Marine, Welding and Nuclear Energy Exhibition

May 1961 monthly 3/6

HOWDEN

Specialists in the design and manufacture of equipment for

MOVING OR COMPRESSING AIR AND GASES

TRANSFERRING HEAT FROM ONE FLUID TO ANOTHER

CLEANING AIR AND GASES

JAMES HOWDEN AND COMPANY LTD

195 SCOTLAND STREET, GLASGOW, C.5, and
15 GROSVENOR PLACE, LONDON, S.W.1

Circle **No 1** on reply card for further details

LIBRARY
THAYER SCHOOL OF ENGINEERING
DARTMOUTH COLLEGE

MEMBER OF THE AUDIT BUREAU OF CIRCULATIONS

VOL. 6 NO 61 MAY 1961

MANAGING DIRECTOR A. H. David Rowse, MA
EDITORIAL DIRECTOR Caldwell Davidson, MSC(ENG), DIC

EDITORIAL
EDITOR John W. Woodeson, BA, BSC(ENG)
ASSISTANT EDITOR J. Spencer Burkett, FLA
TECHNICAL EDITOR David Iggulden, BSC
NEWS EDITOR Sidney Hollands, BCOM
EDITORIAL ASSISTANT Marion Wilson

CONSULTANTS
INSTRUMENTATION Denis Taylor, PHD, MIEE, FIP
PHYSICS James F Hill, BSC
METALLURGY Prof. J. G. Ball, BSC, FIM
REACTORS Robin F. Guard, BSC(ENG)

INDUSTRY GUIDE AND DIGEST NUMBER
EDITOR Charles E. Steiner

PRODUCTION
MANAGER Gerald Vane, BA (CANTAB)
LAYOUT AND TYPOGRAPHY A. Edward Hammond

CIRCULATION
MANAGER J. W. Rotheroe, BSC(ECON)
CIRCULATION ASSISTANT Barbara Stapley

ADVERTISEMENTS
DIRECTOR Harry T. Kane
MANAGER John Abram
SOUTHERN REPRESENTATIVE H. T. Brown
CLASSIFIED ADVERTISEMENTS Michael J. Aplin

BIRMINGHAM OFFICE
27 Cornwall House, 45 Newhall Street
Birmingham 3
tel: Central 3227

MANCHESTER OFFICE
Barry Gibbs
72 Market Street, Manchester 2
tel: Blackfriars 4058
Blackfriars 1919

NEWCASTLE OFFICE
Peter Doig
17 Westgate Road, Newcastle 1
tel: Newcastle 24266

PARIS OFFICE
G. Leterrier,
36 rue du Fer-à-Moulin,
Paris 5eme, France
tel: POR 53-39

U.S. OFFICE
Walter J. Masterson, Jr
Box 206 Essex, Conn. tel: South 7-1838

HEAD OFFICE
The Rowse Muir Building,
77-79 Charlotte Street,
London, W.1, England
tel: Museum 8252
cables: ROWSEMUIR LONDON

NUCLEAR POWER is published by Rowse Muir Publications Ltd, and printed by Eden Fisher (Southend) Ltd, Southend-on-Sea, Essex, England. The entire contents are protected by copyright in Great Britain and by the Universal Copyright Convention and matter may be reproduced only with written permission of the Editor. Subscriptions to publishers Rowse Muir Publications Ltd. One year's subscriptions UK and overseas £2.2.0 USA and Canada $8.00. Three year's subscriptions UK and overseas £5.0.0, USA and Canada $20.00. Single copies UK and overseas 3/6. USA and Canada 75c.

COVER PICTURE

The position of a burst in the AGR will be indicated by the intersection of two lines of light on this presentation panel.

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

SPECIAL FEATURES

The Eurochemic fuel reprocessing plant
The newly completed design for Europe's joint plant, detailed here by Dr T. J. Barendregt, will accept fuel from up to 15 different reactors 59

Reactor instrumentation and control symposium
Dr D. Taylor reports on the recent symposium organized by the Scottish Centre of the Institution of Electrical Engineers and attended by some 120 engineers and scientists 65

Water and steam corrosion of reactor materials
Designed for the study of corrosion effects on power reactor materials, the Sulzer rig, detailed here by Dr F. Muller, has already provided information on zircaloy-2 68

Burst slug detection in the AGR
Mr D. Iggulden looks at the system developed by Plessey incorporating a matrix system and a new eight-way precipitator 71

The Siloe reactor
With a power ten times that of Melusine, Grenoble's second experimental reactor is expected to operate early in 1963 74

Refuelling the AGR
One of the first two combined-purpose installations to operate on-load anywhere in the world, the charge machine, described here by Mr J. Spencer Burkett, is due for installation in the near future 75

The Engineering Exhibition—1961
Over 500 firms are represented and, from the large range of engineering equipment shown, Nuclear Power selects those items of interest to the nuclear engineer 78

Irradiation techniques — 5
This month, Mr O. S. Plail turns his attention to the techniques developed at Harwell for the high activity handling methods involved in detailed metallurgical examination 82

REGULAR FEATURES

Research and development
Manipulator development in the USA, glass fibre fuel elements, etc. 87

Letters	49	Cross-Section *Gracchus*	94
Editorial	51	Business News	96
Worldview	53	People	98
New Product Survey	89	Diary	100
Students' Notebook	92	Industrial Literature	100
Points from Papers	93	Book Reviews	102

Index to Advertisers 126

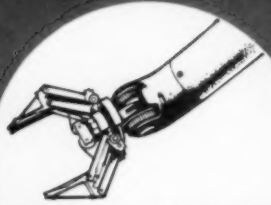
LOOKING FOR A JOB? SEE PAGE 124 AND ONWARDS © 1961

RM ROWSE MUIR PUBLICATIONS LTD, LONDON, ENGLAND

The outstanding N|E|L PLANS service

What makes the NEL Plans service so important? It includes complete and detailed preparation of layouts for any remote handling project. It enables you to build with confidence and to use the standard arms successfully even for highly specialised requirements. This cuts down installation costs so it pays to consult NEL early.

NEL



NE8 For lifting and handling R-A materials weighing up to 7 lb. The equipment has power driven side-swing movements.

NE9 Highly manoeuvrable unit, with maximum capacity of 100 lb.

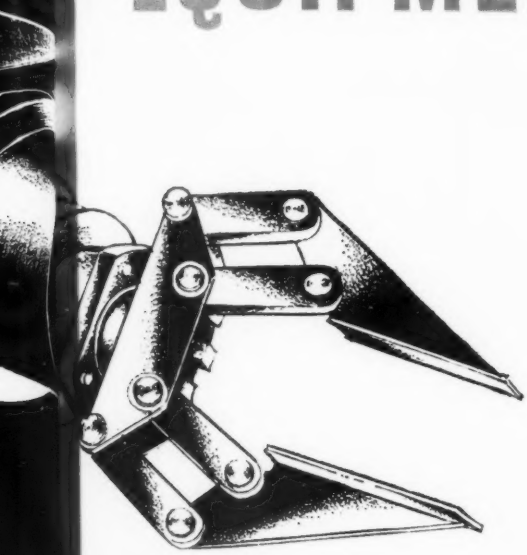
M100 Low cost system with full cell coverage and 200 lb. lift.

M150 Maximum manipulating facilities in minimum space, e.g. Alpha-Gamma handling in sealed dry box.

World's largest range of NUCLEAR HANDLING EQUIPMENT

Circle **No 3** on reply card for further details

THE M300



The M300 is a versatile 'all-purpose' unit from the wide NEL range. It is a standard mechanical arm with a lifting capacity from a few ounces up to 750 lb. and its many special features include minimum headroom configurations where overhead clearance requirements are vital. Like all NEL equipment, the M300 is backed by outstanding service and the unique NEL plans service.

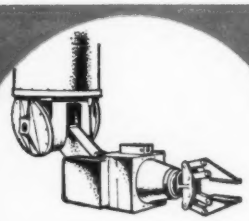
NUCLEAR EQUIPMENT LIMITED

Combining the knowledge, equipment and planning resources of two great nuclear handling companies : Savage and Parsons Limited of England and General Mills Inc., of the U.S.A.

OTTERSPOOL WAY · WATFORD · HERTFORDSHIRE · WATFORD 26077

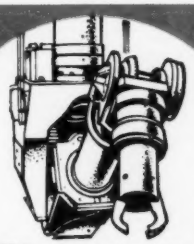
Technical literature on all these types is available from NEL.

Eight standard mechanical arms are provided in the range, with electric drives, variable speeds, finger-tip controls and automatic connections for power tools.



M500 Basically similar to M300. Handles up to 2,000 lb. with fine control.

M550 Wide versatility of heavy load application, e.g. 100 lb. cantilevered 18 ft.



M700 Heavyweight unit with rigid hook for lifting loads up to 5,000 lb.

the SERCK organization

is actively concerned in the supply of equipment and material with special application to the Nuclear Power Industry

PRIMARY AND SECONDARY SURFACE

HEAT EXCHANGERS, CONDENSERS,

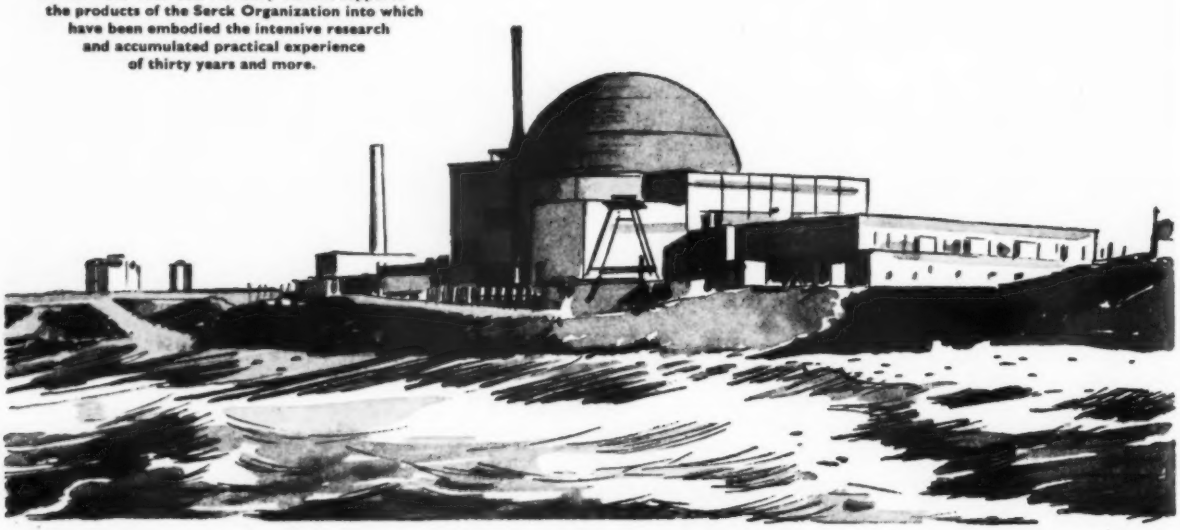
AIR AND GAS COOLERS,

SERCK RADIATORS LIMITED

WARWICK ROAD, BIRMINGHAM 11

member of the SERCK GROUP

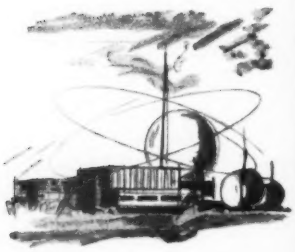
A first class Technical Advisory Service supports the products of the Serck Organization into which have been embodied the intensive research and accumulated practical experience of thirty years and more.

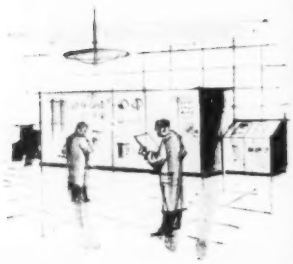


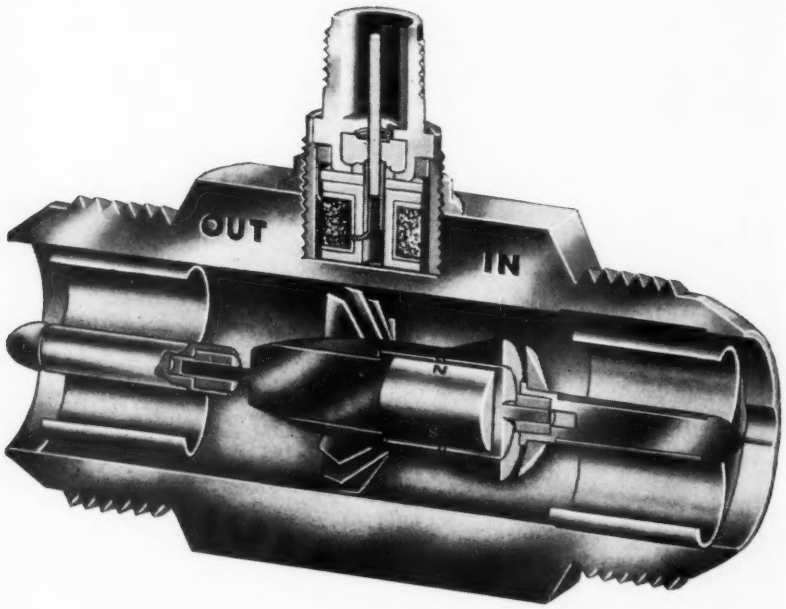
Wherever information on fluid flow is required,

the de Havilland POTTERMETER

sets new standards of accuracy and reliability







This new turbine-type flowmeter enables major advances to be made in the techniques of flow measurement and control. The de Havilland Pottermeter is the only flowmeter which offers all these features:

Contains only one moving part — no thrust bearings — operates with a minimum of maintenance at high temperatures and pressures

Accuracy to ± 0·1% or better on repetition work, ± 0·5% or better over a 20·1 range. Calibration remains constant for a variety of liquids over wide flow ranges.

No larger than the pipeline in which it is installed — may be mounted in any attitude.

Can be supplied with indicating, recording and process control equipment — gives digital presentation of results.

Can measure volumetric or mass flows.

Models available to measure flows from 0·1 to 40,000 Imperial gallons per minute, at a wide range of operating pressures. Larger and smaller sizes made to order.

Can measure flow of any liquid or gas, irrespective of its lubricating or non-lubricating properties, at temperatures ranging from −455°F to 1500°F.

Manufactured as standard in stainless steel — can be made in any non-magnetic material.

Rapid response rate permits transient flow studies.

The Pottermeter is a product of the engineering teams which have been responsible for the design, development and manufacture of de Havilland propellers and of the Firestreak guided weapon.

Write now for further details to:

THE DE HAVILLAND AIRCRAFT CO. LIMITED

HATFIELD, HERTS

Member Company of the Hawker Siddeley Group

Circle **No 5** on reply card for further details

The **SPRITE CO_2** Welding Unit, showing the Remote Amperes Control Box for 'on the spot' control of welding current and the Lincoln FW.1 CO_2 Hand Welding Gun.

SPRITE CO_2 WELDING

- is simple to operate
- is exceptionally versatile
- is up to 50% faster than older methods of manual welding
- eliminates electrode changes, wasteful stub ends—gives maximum welding time
- solves de-slagging problems—as the arc is shrouded with CO_2 gas, little or no slag is formed on the weld, thus saving clean-up time.

In short, SPRITE CO_2 Welding means faster, better welding at lowest cost!

Look Spritely—get more information *now* from:

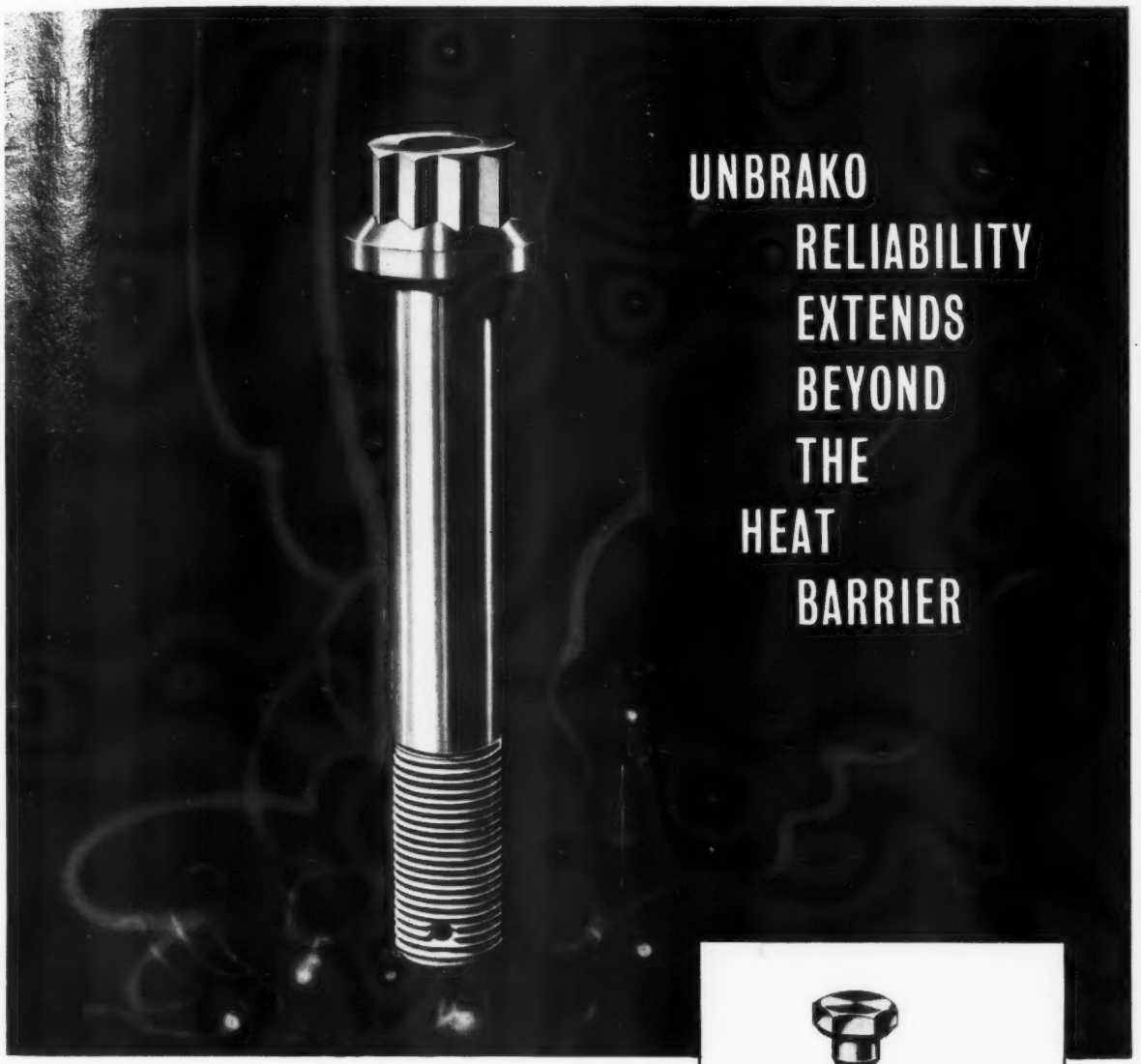
LINCOLN ELECTRIC
COMPANY LIMITED

Welwyn Garden City • Herts • England • *Tel:* Welwyn Garden 24581
Cables and Grams: Shield Arc • Welwyn Garden City

A MEMBER OF THE GKN GROUP OF COMPANIES

17/61

Circle **No 6** on reply card for further details



We live in exciting times. Man's knowledge has assumed seven league boots and leads him across fresh frontiers every day. But new territory is fraught with new dangers, many of which can only be guessed at. The next stepping stone for our aircraft is the heat barrier. Here, as before, complete safety will depend on the reliability of every component part used. Unbrako make fasteners for these aircraft of tomorrow. We do not rely only on our long experience in this field. In our Advanced Design Division, a team of highly skilled engineers are constantly probing and testing, helping us to make fasteners that do more than satisfy today's requirements — fasteners with a safe place in the future.

UNBRAKO AD*

Advanced Design Division

UNBRAKO SOCKET SCREW CO. LTD.-COVENTRY. TEL: 89471.

★ A BASCODUR VALVE IS ACID RESISTANT

★ BASCODUR is a special thermo-setting synthetic material . . . with high thermal stability . . . with excellent corrosion resistance to acids, alkalis and solvents—and especially acids flowing at high temperatures.

ON STAND NUMBERS

35 INNER ROW GALLERY GRAND HALL

11A ROW A GROUND FLOOR, GRAND HALL

ENGINEERING, MARINE, WELDING and NUCLEAR ENERGY EXHIBITION

Write for leaflet N1

I.V. PRESSURE CONTROLLERS LIMITED

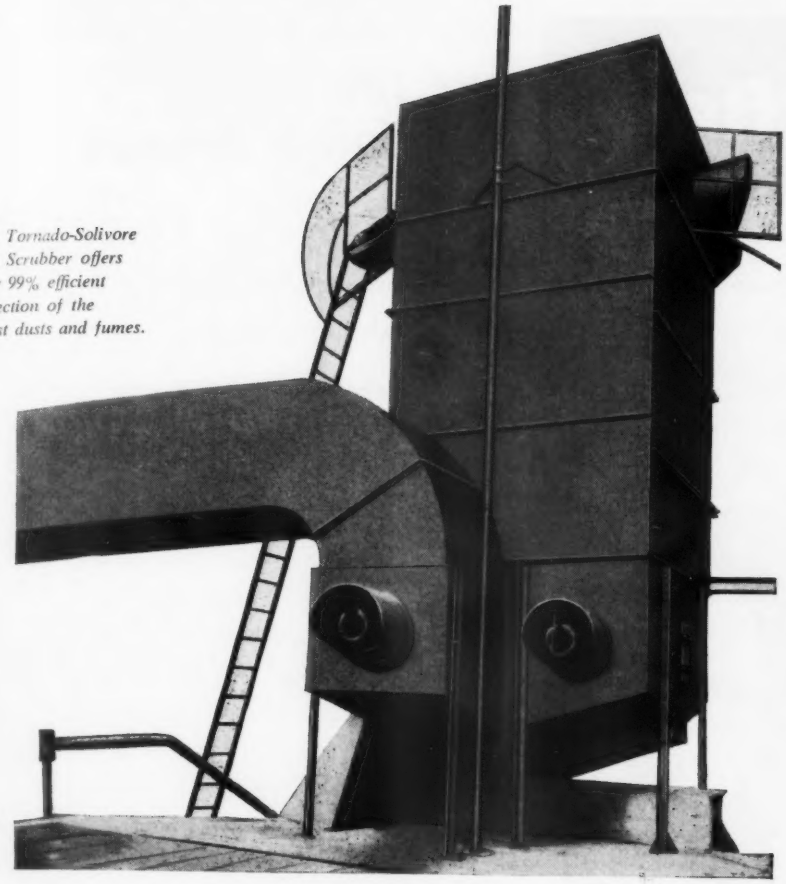
SALES OFFICE: ATLAS HOUSE 683 LONDON ROAD ISLEWORTH MIDDLESEX

Telephone: Isleworth 7273/4/5

A MEMBER OF THE METROPOLE GROUP OF COMPANIES

P6347

Circle No 8 on reply card for further details



The Tornado-Solivore Wet Scrubber offers over 99% efficient collection of the finest dusts and fumes.

when the problem's

DUST FUMES

turn to 'Tornado'

For over 60 years, Industry has turned to 'Tornado' to settle dust and fume extraction problems. Keith Blackman were the first in the country to use air extraction as the basis for dust and fume exhaust systems. With this record and this experience they are the natural choice for your problem. You too, should 'turn to Tornado' for advice on *complete plants* or individual equipment. There is a qualified representative in every industrial area.

Keith Blackman Ltd

Dust and Fume Control Division

MILL MEAD ROAD, LONDON N.17 TOTTENHAM 4522 TA 3691/1070

CLOTH FILTRATION

Tornado-Fischer patented, self-cleaning filters

Type 270/540 pocket filters

Series TF dust collectors

Series T self-contained dust collectors

WET FILTRATION

Solivore patented wet scrubbers

Hydro precipitator wet washers

CENTRIFUGAL FILTRATION

Cyclogal high efficiency, low resistance cyclones

Cyclogalax 'straight through' cyclones

Standard cyclones

PD-KB tubular collectors

ELECTROSTATIC PRECIPITATION

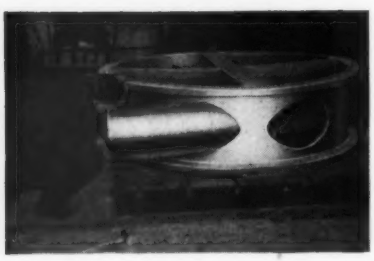
PD-KB electrostatic precipitators

FANS

Paddle type industrial fans

Butterfield *and the Aluminium Bronze Age*

Butterfields have made a successful and important advance in the Welding of Aluminium Bronze Alloys which are highly resistant to sea water — a big anti-corrosion feature in fabrications for the Nuclear Engineer



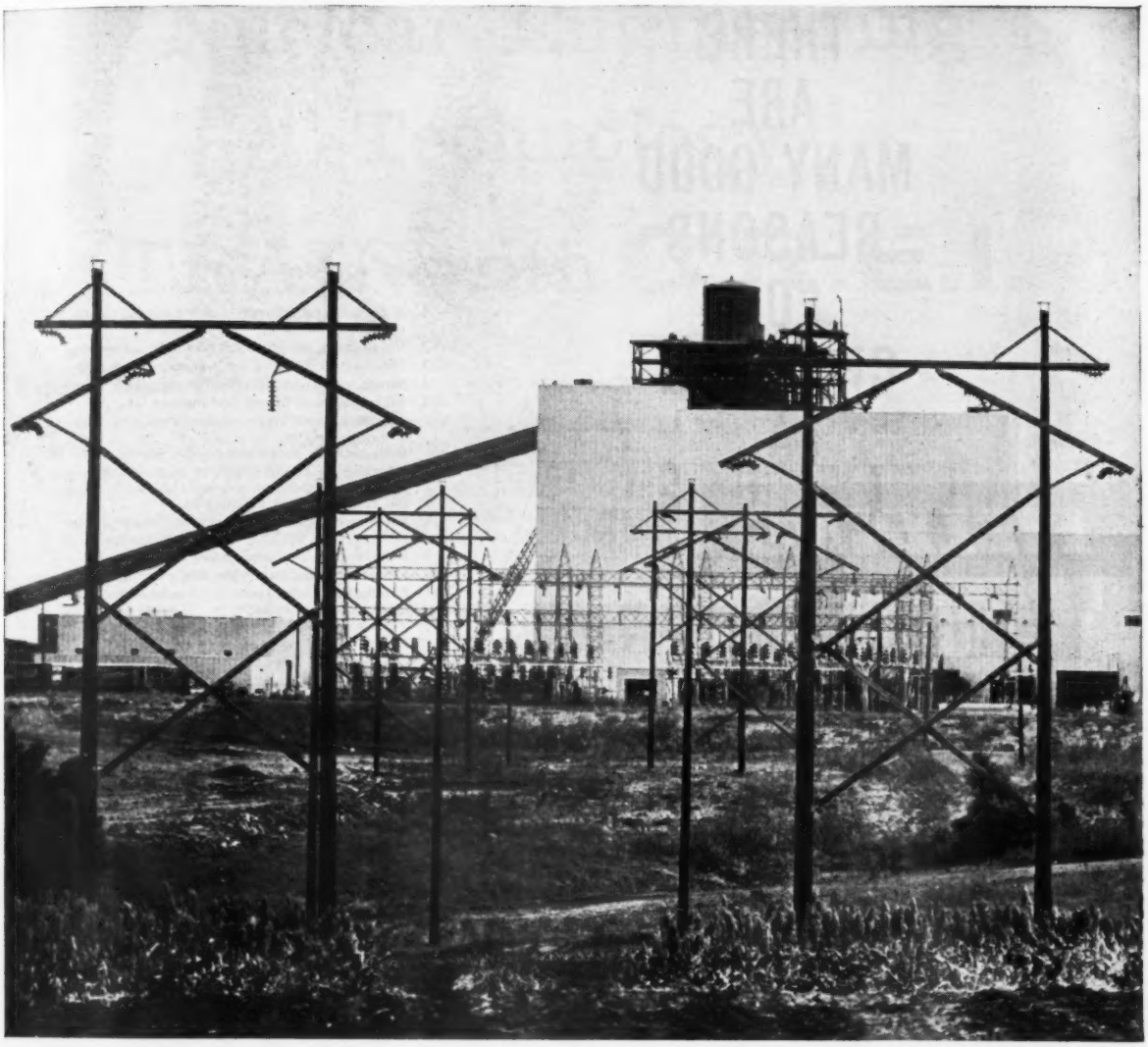
The Aluminium Bronze water and return box equipment illustrated, was fabricated and welded by Butterfields in co-operation with N. C. Ashton Ltd., who supplied the plate, forgings and welding wire. Welding throughout was by inert gas processes, and mainly by inert-gas metal-arc. Demonstrating how effectively these anti-corrosion Alloys can now be welded to other materials, the mild steel flanges in this equipment were layered with Aluminium Bronze.

Our smaller illustrations show (vertical) the welding of branches into water boxes, and (horizontal) assembly of lobster back branches into barrel of water boxes

W. P. BUTTERFIELD (*Engineers*) **LTD.**
P.O. Box 38 · Shipley · Yorkshire
Telephone: 52244 (8 lines)

BRANCHES:
London Tel: HOLborn 2455 (4 lines)
Birmingham Tel: EAS 0871 & EAS 2241
Bristol Tel: 27905
Liverpool Tel: CENtral 0829
Glasgow Tel: CENtral 7696
Belfast N.I. Tel: 57419 & 51957
Dublin Tel: 73475 & 79745

75,000 KW Sodium Graphite Reactor station for Consumers Public Power District at Hallam, Nebraska, U.S.A.



The Peaceful Atom

Helping the world double its power supply in the next ten years

The fuel of the future is in the atom. But even now, lights are burning, wheels are turning, thanks to atomic fuel. Atomics International, a world-wide leader in high-performance reactor systems, has over 15 years' experience in designing, constructing, and operating reactors. Two of the world's most advanced atomic power stations are now being built by AI under U.S. Atomic Energy Commission programs. The wealth of experience and facilities at AI will help the world's power-producing companies in their plans to double the supply of electricity in the next ten years.

ATOMICS INTERNATIONAL DIVISION OF NORTH AMERICAN AVIATION, INC.

Pioneers in the creative use of the atom

Affiliated with: INTERATOM, Bensberg/Cologne, Federal Republic of Germany

EUROPEAN HEADQUARTERS: North American Aviation S. A., 29 Rue de la Coulouvrenière, Geneva, Switzerland. *Affiliated with:* DYNATOM, Paris.

WORLD HEADQUARTERS: Canoga Park, California, U.S.A. Cable Address: ATOMICS

Other Offices: Washington, D.C., U.S.A.

Circle **No 11** on reply card for further details

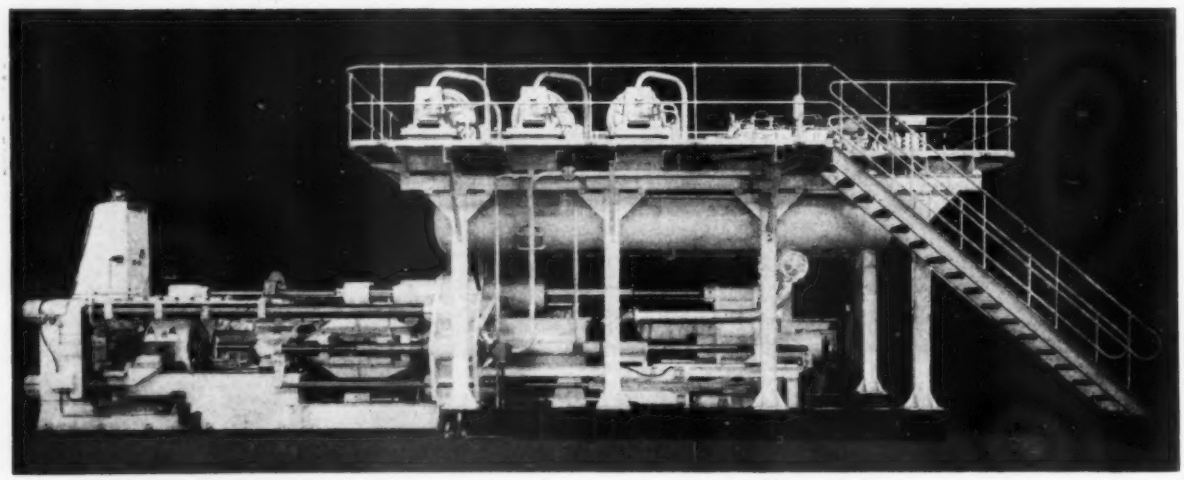
THERE ARE MANY GOOD REASONS FOR CHOOSING A

FIELDING

EXTRUSION PRESS

here are just a few ....

1. A complete self-contained unit designed to stand on the shop floor.
2. Four-column design affords maximum accessibility.
3. Short dead cycle time for maximum productivity.
4. Simple, robust and trouble-free auxiliaries.
5. All cylinders are forged steel for long life.
6. Central long-stroking container moving cylinder, ensuring smooth movement of the container throughout its stroke and positive sealing.
7. Ram crosshead and container housing fully supported and guided on the bed-plates with simple but effective means of lining-up.
8. Extra quick change facilities for container and pressing stem.
9. Induction or resistance heated containers.
10. Compact internal mandrel moving/piercing cylinder.
11. Pushbutton operated control for independent, hand or automatic cycle.
12. All press motions fully interlocked.
13. Positive pre-selected control of ram speed.



A 'FIELDING' 1000 Tons Horizontal Self-Contained Semi-Automatic Extrusion Press installed in a customer's works in Australia.

14. A specification which defines the exact extent of supply—the best value for money.
15. Almost 100 years' experience is built into every press and backed by the 'FIELDING' reputation for service.
16. Every press erected and tested on our shop floor before delivery.
17. Agents throughout the world.

Fielding & Platt Limited

GLOUCESTER · ENGLAND

Member of the Heenan Group

Nuclear Engineering Technology

TRAIN with C.R.E.I.

WHO C.R.E.I. ARE

C.R.E.I. (The Capitol Radio Engineering Institute) was founded in America 34 years ago. It is well-known for its residential college in Washington and also for its unique procedures in offering students unable to undertake full-time study an equivalent education conducted in their own time and at their own pace. Many of the leading electronics engineers in American Industry and in the American Services are C.R.E.I. trained. At this moment over 20,000 students in the United States alone are taking C.R.E.I. home study courses.

C.R.E.I. HOME STUDY COURSES ARE NOW AVAILABLE FROM GREAT BRITAIN

Accepted in the United Kingdom for part refund of fees to members of the three Services, C.R.E.I. courses offer serious-minded students determined to further their careers the following distinct advantages:

1. Through step-by-step tuition by highly-qualified tutors possessing up-to-the-minute knowledge of technological development and industrial requirement.
2. Courses that are being continuously revised to keep pace with technological advancement—in this way the inevitable out-of-dateness of text books is avoided.
3. Individual tuition. The 'relationship' between student and tutor is a personal one in the sense that the student's individual requirements and progress are taken into account, throughout the course. There is no question of proceeding at the rate of a class. Your 'class' with C.R.E.I. consists of one person—you.

OPPORTUNITY is boundless — for the qualified

C.R.E.I. courses call for hard work and personal discipline, essential requirements for a successful career. C.R.E.I. qualified men are able to do more important work with accompanying rewards.

C.R.E.I. Courses are available in:

(I) Nuclear Engineering Technology
(II) Electronic Engineering Technology
(III) Mathematics for Electronic Engineers
(IV) Automation
(V) Radar
(VI) Servo

If you have at least two years practical experience in electronics or a suitable educational background, fill in this coupon now for full details of C.R.E.I. courses, methods and achievements.

TO: C.R.E.I. (LONDON), (DEPT. NPI) GRANVILLE HOUSE, 132/135 SLOANE STREET, LONDON, S.W.1.

Please send me (for my information and entirely without obligation) full details of the Educational Programmes offered by your Institute.

NAME .....

ADDRESS .....

.....

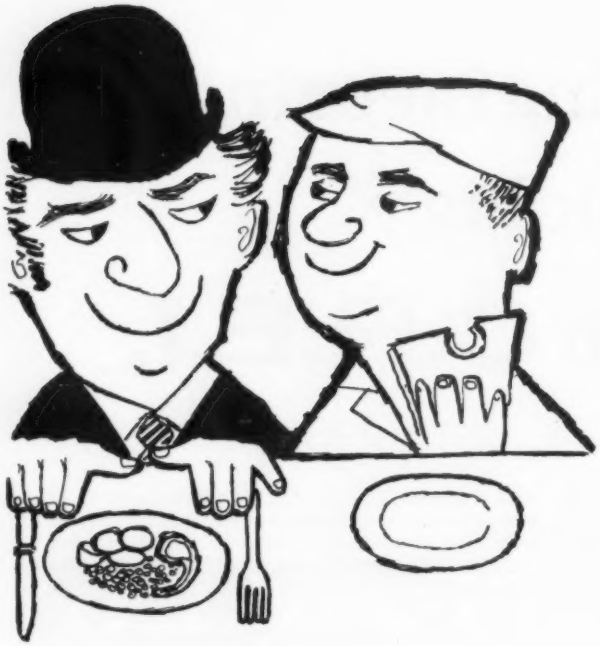
BACKGROUND EXPERIENCE .....

.....

.....

C.R.E.I. (LONDON), (DEPT. NPI) GRANVILLE HOUSE, 132/135 SLOANE STREET, LONDON, S.W.1.

Circle No 13 on reply card for further details



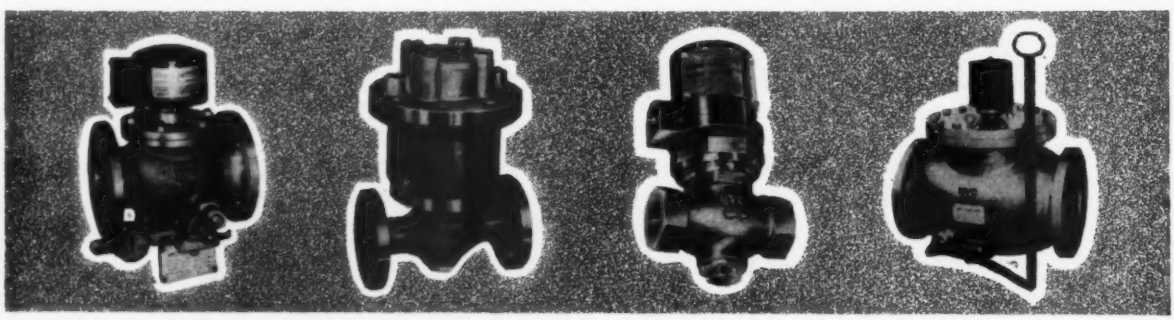
WE OFTEN TALK 'SHOP' AT LUNCH

(Because we like to thoroughly digest our customers problems!).

We like to see a job well done. And we like to see our customers happy! Getting our teeth deeply embedded in to our customers' problems—no matter how specialised and individual—is the backbone of the MVC Service!

Over 30 years' experience and 'know-how' has been built-in to our range of over 100 automatic control valves. People control water with them, gas with them, oil with them, steam with them and a host of other industrial liquids and gases too. Mushrooms are grown with them, jam is made with them and ships' cargoes are frozen with them!

You'll find that expert consultation and advice cost you absolutely nothing at MVC. Our full experience is at your disposal. Many times, what has first appeared to be impossible has been achieved. Why not write **now** for our new comprehensive catalogue No. M122, which contains full details of our complete range!



MVC

The Magnetic Valve Company Ltd

7 KENDALL PLACE · BAKER STREET · LONDON · W.1. HUNTER 1801

EMI extends nuclear health coverage

WITH THE NEW SINGLE HAND MONITOR FOR THE SMALLER ESTABLISHMENT

The latest addition to EMI's range of Nuclear Health Devices . . . a Radiation Monitor for the smaller establishment where radio-active materials are handled.

* Transistors ensure accuracy and reliability, with low power consumption.
* Audio and visual alarms.
* Dual phosphor scintillation counters check contamination in as little as 5 seconds.

in addition to these brilliantly successful EMI units

THE HAND AND CLOTHING MONITOR

Specially designed to speed the checking of large numbers of staff, screening three workers at once for Alpha and Beta contamination of hands, clothing and footwear. Dual phosphor scintillation counters. Automatic correction for background radiation. Large numbers in use with UKAEA and authorities overseas.

THE PORTABLE MONITOR

A versatile instrument, whose range has now been extended by the addition of several interchangeable probes. Compact mobility plus high accuracy have been achieved by combining all-transistor circuitry with EMI dual phosphor technique. Battery or mains operation.

Write or telephone for a demonstration, or for the new Nuclear Health Short Form Catalogue:

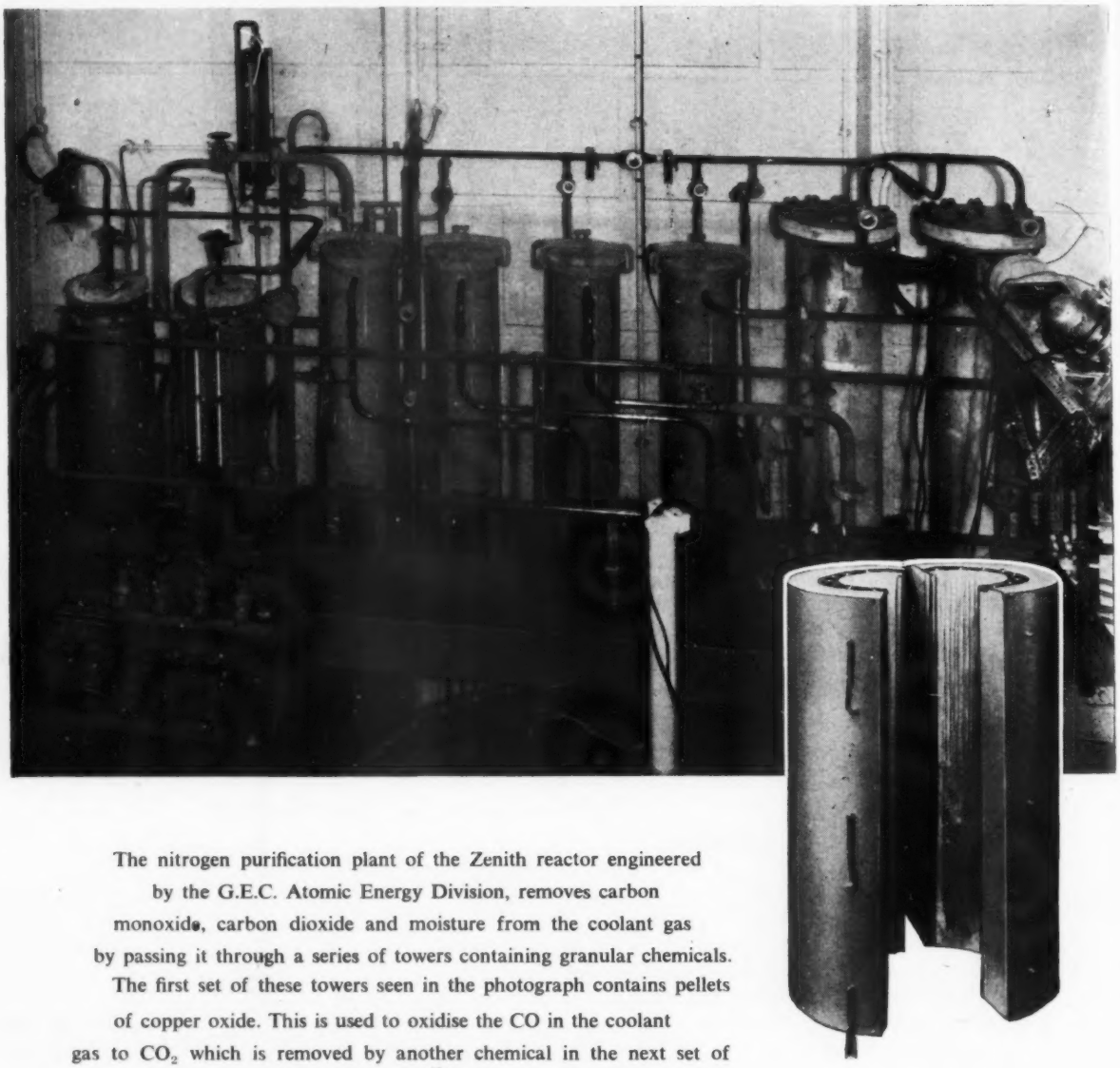
EMI ELECTRONICS LTD

Instrument Division · Hayes · Middlesex · Tel: Hayes 3888 Ext. 2223

EMI

ISOJACKETS

on Zenith Reactor...



The nitrogen purification plant of the Zenith reactor engineered by the G.E.C. Atomic Energy Division, removes carbon monoxide, carbon dioxide and moisture from the coolant gas by passing it through a series of towers containing granular chemicals. The first set of these towers seen in the photograph contains pellets of copper oxide. This is used to oxidise the CO in the coolant gas to CO_2 which is removed by another chemical in the next set of towers. For the copper oxide bed to react in this way it has to operate at a temperature of 400-450°C. and the pellets are most conveniently raised to this temperature by Isojackets.

These hinged Units comprise the heating surface, thermal lagging and outer metal casing, and are used in many other Nuclear Plants.

ISOPAD ELECTRIC SURFACE HEATERS

ISOPAD LTD., BARNET BY-PASS, BOREHAM WOOD, HERTS.
Telephone: ELStree 2817/9 & 3602

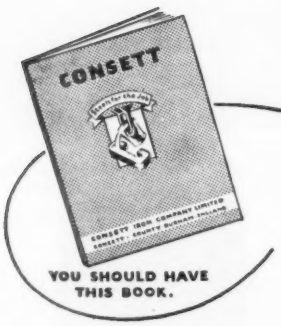
Reproduction of 16th century Dutch Print by Amman, illustrating the craft of the Knife-Grinder. (Copyright, Radio Times—Hulton Picture Library).

Every man to his own trade—

and our trade is STEEL!

Not only mild steel for everyday use but also the special steels demanded by the Nuclear Age . . .

Consett nuclear steels were selected for use in the British Nuclear Plants at Bradwell, Chapel Cross, Calderhall and now Dungeness, as well as the new Italian plant at Latina.

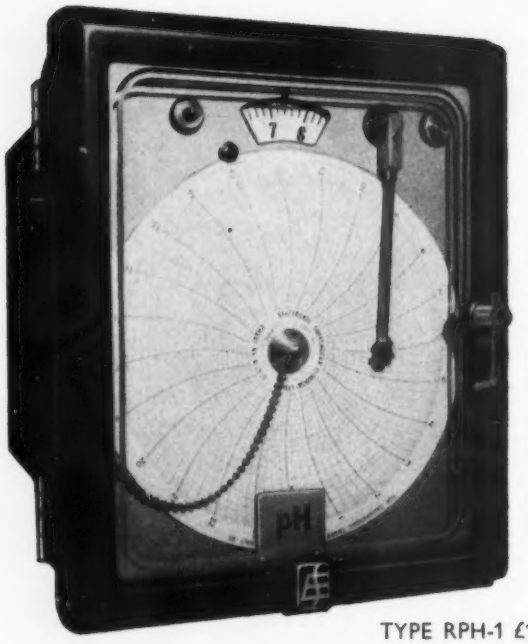


An interesting booklet "Steels for the Job", published by us, describes some of our newer products. We shall be delighted to send you a copy.

Our Technical and Research Department will also welcome enquiries from any whose problem is . . . **STEEL**

CONSETT IRON COMPANY LIMITED, CONSETT, COUNTY DURHAM

Telephone: Consett 341 (12 lines) Telegrams: Steel Phone Consett



TYPE RPH-1 £188

The 3 in 1 pH SYSTEM

MEASUREMENT • RECORDING • CONTROLLING

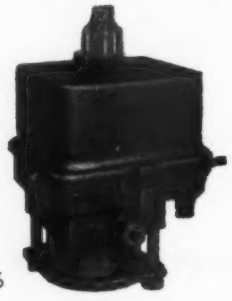
are performed by a single instrument connected to a suitably selected pH electrode system.

The System

- **REPLACES costly composite instrument systems**
- **SAVES valuable instrument panel space**
- **SIMPLIFIES setting – by single knob adjustment**
- **ELIMINATES frequent calibration checks**
- **PROVIDES high and low level alarm or control switching**

Write for literature on Industrial pH, conductivity and level control instruments.

Industrial Electrochemical Instruments



HPF/T electrode system £46

ELECTRONIC SWITCHGEAR (LONDON) LTD · LETCHWORTH · HERTS · TEL: 1853

REFUELLING at Windscale by JOHN BROWN

This Refuelling Machine which is 60 feet high and weighs approximately 400 tons, is to be installed by the U.K. Atomic Energy Authority at Windscale. It will be used for charging and discharging the advanced gas cooled reactor, and is designed to be automatically positioned over any selected reactor charge tube to within .005 inches.

Two pressure vessels are mounted in the support structure; one for normal reactor charge and discharge, the other for broken fuel elements etc. These vessels are surrounded by 22 inches of cast iron gamma ray shielding and 9 inches of fast neutron shielding.

The normal handling vessel is 21 inches in diameter and contains a rotating magazine with three compartments—for storing an irradiated fuel element, a new element and a stand-by reactor seal plug.

Extending below each vessel is a retractable nose unit which connects and makes a pressure tight joint with the reactor charge tubes as required. These nose units also carry the sensing devices for fine positioning the machine.

Because the charging and discharging of the reactor must be carried out under full load conditions, special electrical and mechanical controls including television equipment will be provided to ensure ease of operation and maximum safety.

Built by Markham & Co. Ltd., Chesterfield, a subsidiary of John Brown & Co. Ltd.

JOHN BROWN (S.E.N.D.) LIMITED

20, EASTBOURNE TERRACE, PADDINGTON, LONDON, W.2

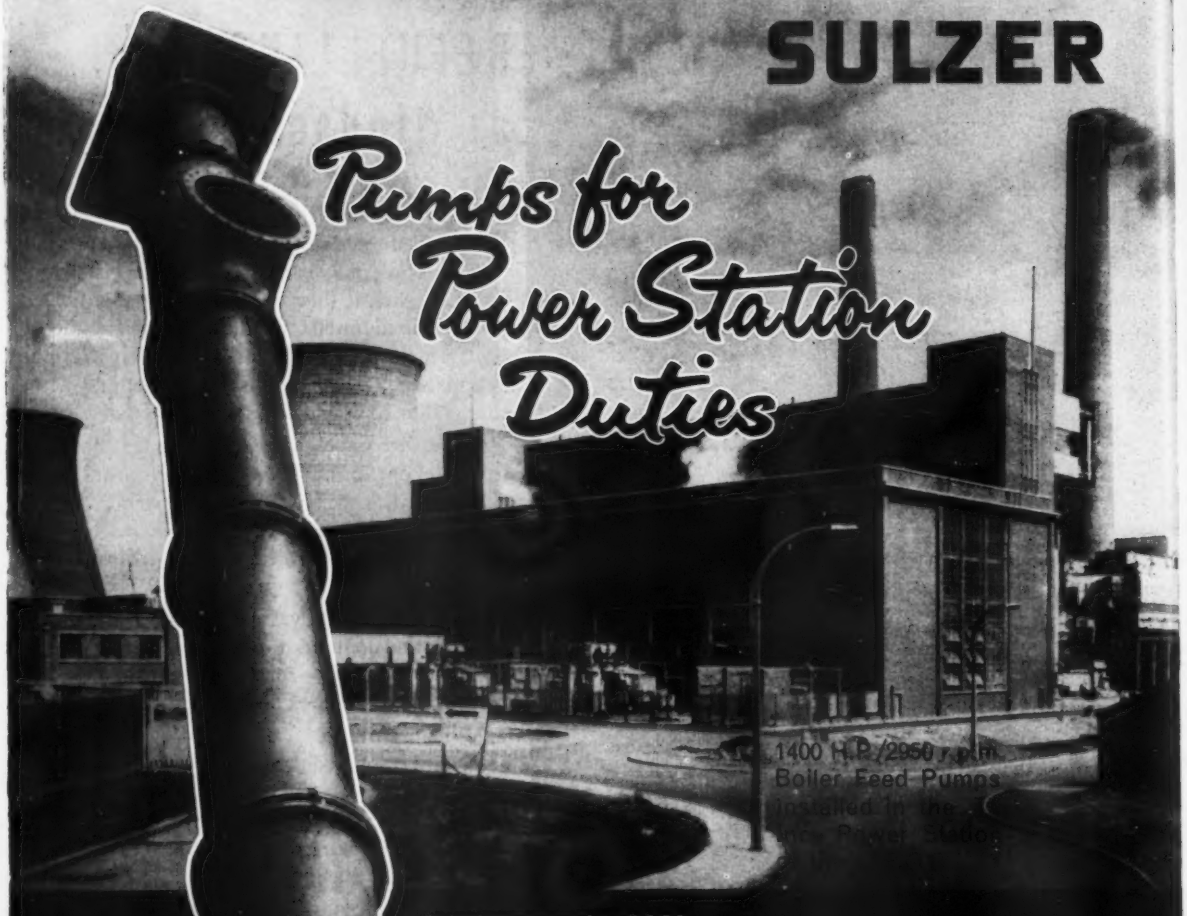
Telephone: PADDINGTON 3474, Telex: 21317

Telegrams: JABEND WESTPHONE LONDON

Circle No 19 on reply card for further details

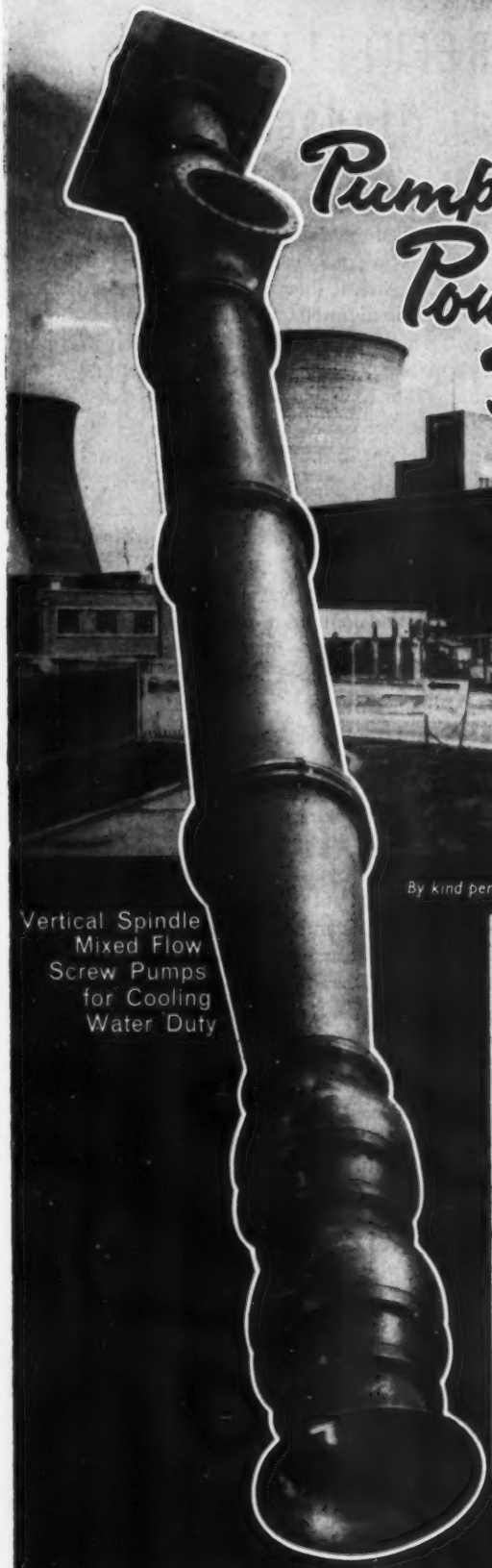
SULZER

Pumps for Power Station Duties

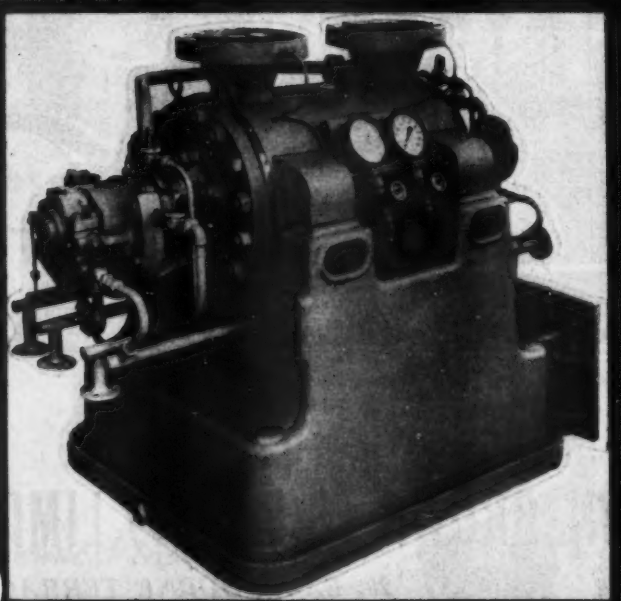


1400 H.P./2950 r.p.m. Boiler Feed Pumps installed in the [illegible] Power Station

By kind permission of the C.E.G.B.



Vertical Spindle Mixed Flow Screw Pumps for Cooling Water Duty



SULZER BROS. (LONDON) LTD.
(Incorporating Hathorn Davey & Co. Ltd.)
31 Bedford Square, London, W.C.1.

INNOCENTI

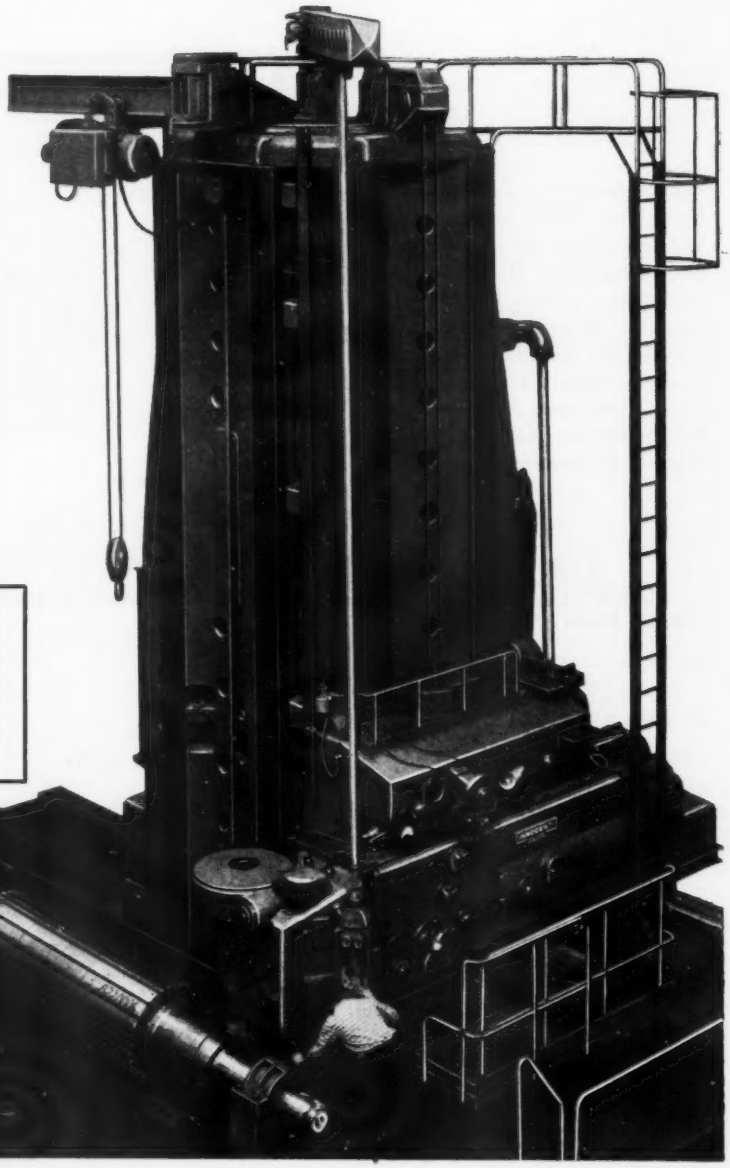
Maximum power, precision and production potential . . .

are essential characteristics of INNOCENTI-CWB Milling and Boring Machines

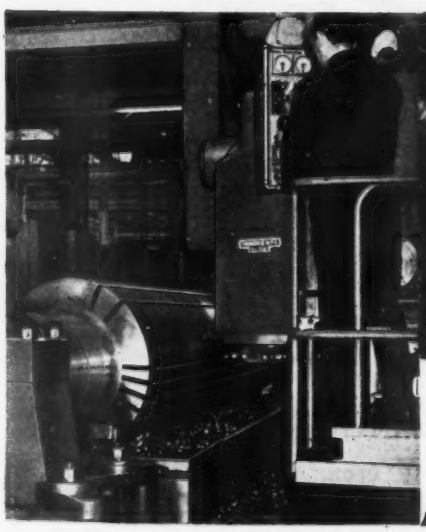
ADDITIONAL IMPORTANT FEATURES:

Maximum versatility • Economical production • Jig boring facilities • Large diameter surfacing and boring at right angles to main spindle • D.C. variable speed motors • Sliding headstock • Virtual elimination of boring bars • Facilities for copying • Facilities for automatic remote control electric measuring and for programme control • All-electric—no electronics • Minimum maintenance • Remote pendant control of entire machine.

Further information available on request.



Slotting of heavy turbo-alternator rotor using standard rotor slotting attachment capable of transmitting full machine power of 100 H.P. to cutter. Attachment on a standard Innocenti—CWB Heavy Universal Precision Milling and Boring machine FAF 200, 8" spindle. This arrangement offers the production possibilities of a special purpose rotor slotting machine combined with the high degree of machine utilization afforded by a heavy multi purpose machine tool.



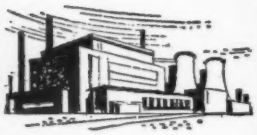
Inserted by Henderson & Keay Ltd., Agents in Great Britain for INNOCENTI Mechanical Division, Milan.

HENDERSON & KEAY LTD., 189 PITT STREET, GLASGOW C.2.

Telephone: CENTRAL 0261

THERMAL INSULATION BY Newalls

Throughout the years Newalls have built an enviable reputation in the insulation of conventional power stations. This specialised experience is now being drawn upon on an ever growing scale in solving the complex problems of Nuclear Power Development. Recent contracts in this field reflecting Newalls supremacy are:—



HINKLEY POINT

C.E.G.B. NUCLEAR POWER STATION

At Hinkley Point, Newalls have been entrusted with the insulation of the reactors, steam raising units, gas ducting, integral piping, etc., under contract to Babcock and Wilcox Ltd.

CHAPELCROSS

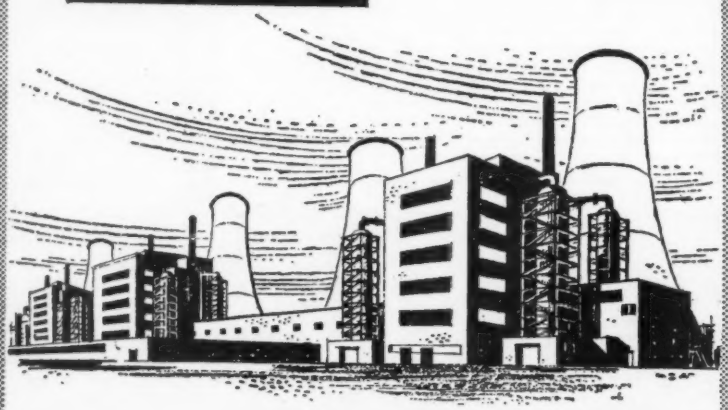
U.K.A.E.A. NUCLEAR POWER STATION

Under contract to Babcock and Wilcox Ltd., Newalls have carried out the insulation of the 16 steam raising units and integral piping. The insulation of turbines, blowers, associated auxiliary equipment and piping has been carried out under contract to C. A. Parsons and Co. Ltd.

BRADWELL

C.E.G.B. NUCLEAR POWER STATION

At Bradwell-on-Sea a further large contract for the thermal insulation of turbines, associated auxiliary equipment and piping (main and auxiliary turbine plants) has also been placed by C. A. Parsons and Co. Ltd. with Newalls.



NEWALLS INSULATION COMPANY LIMITED

Head Office: WASHINGTON, CO. DURHAM.
A member of the TURNER & NEWALL ORGANISATION.

Offices and Depots at: LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL and CARDIFF. Agents and Vendors in most markets abroad.

74

exceeded in recent tests!

result of gas circulator tests with Stillite Filter Pads was 99·9975% efficiency

Stillite filter pads are fitted for oil vapour removal in the carbon dioxide clean-up circuit on the gas circulators used on the primary gas circuits for the HERO reactor now being erected at Windscale for the UKAEA. Tests on the filter carried out by De Havilland who are constructing these circuits have shown that a consistent efficiency of 99.9975% is achieved over a simulated 8000 hours run. This performance was superior to any that could be obtained from standard filters.

Stillite filter pads provide a filtration medium able to meet the most exacting requirements even when used for the filtration of hot corrosive gases. Please send coupon for full details.

STILLITE

Regd. Trade Mark

To STILLITE PRODUCTS LTD · 15 Whitehall, London, S.W.1.

Please send me Technical Data TD4 on Filtration

NAME .....

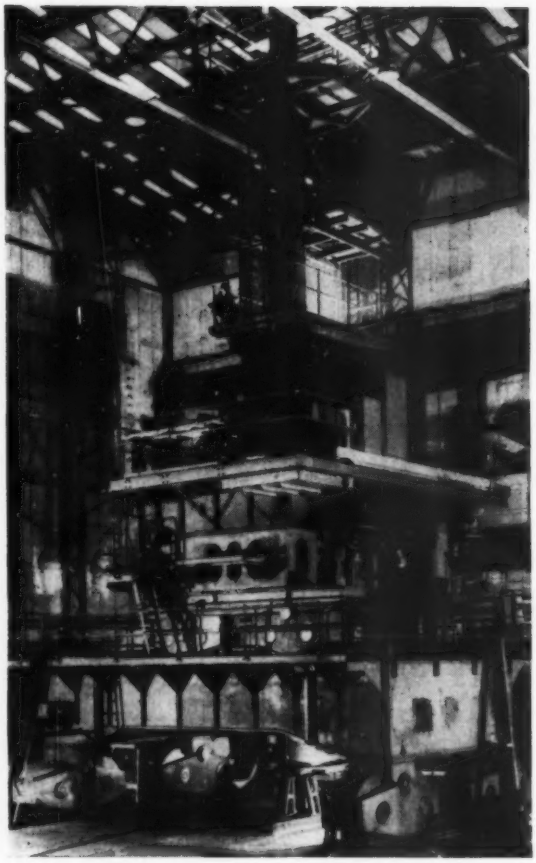
ADDRESS.....

Just attach to letterhead *Nuclear Power*

STILLITE PRODUCTS LTD., 15 WHITEHALL, LONDON, S.W.1. *TEL: WHItehall 0922/7.*

Member of the TURNER & NEWALL ORGANISATION

JABROC N



FAST NEUTRON SHIELDING

chosen by

JOHN BROWN (S.E.N.D.) LTD.

for the

A.G.R. REFUELLING MACHINE

Over 800 cubic feet of Jabroc N Shielding, including complex machined parts, have been specified on this machine.

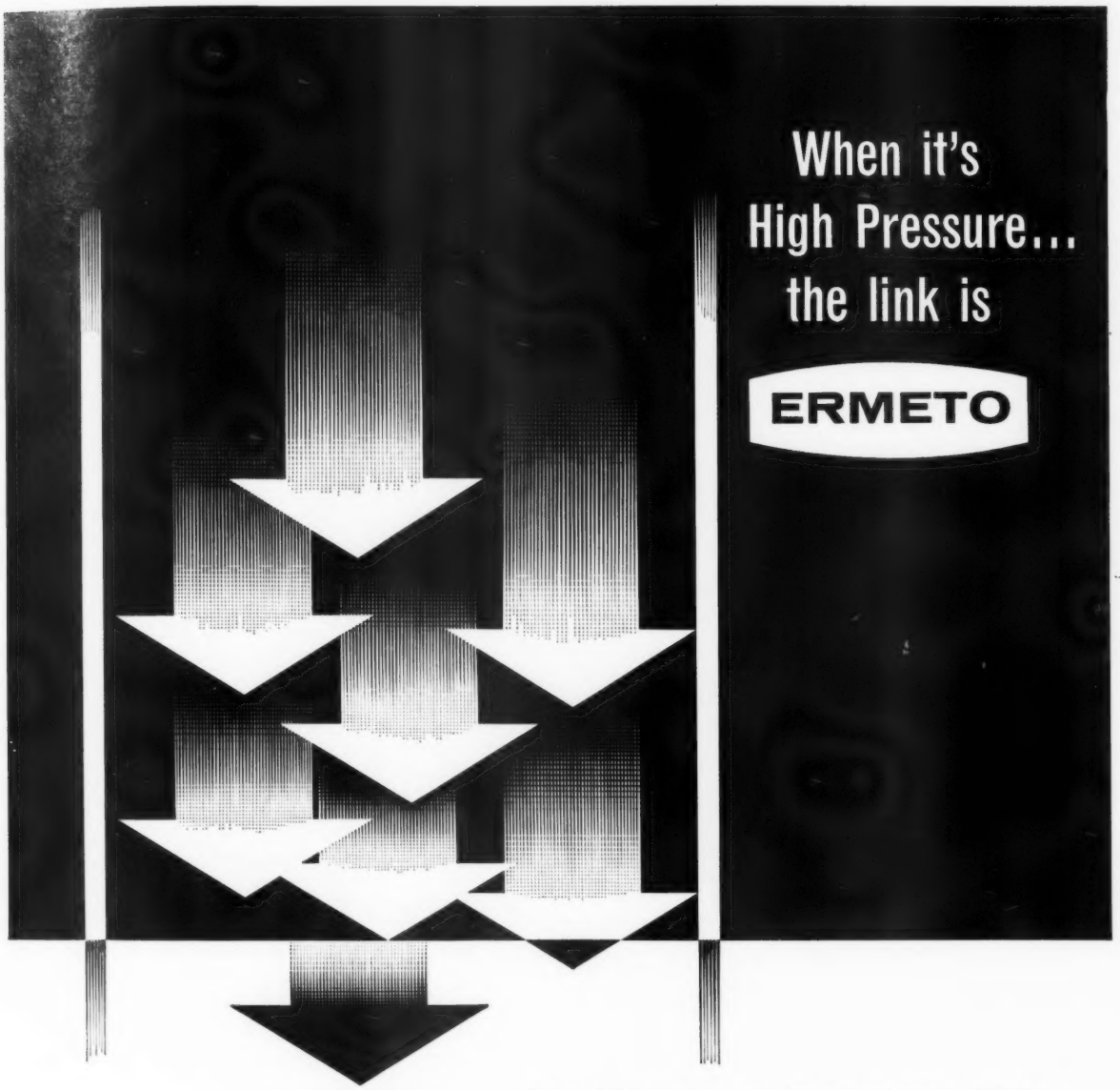
A totally tested product

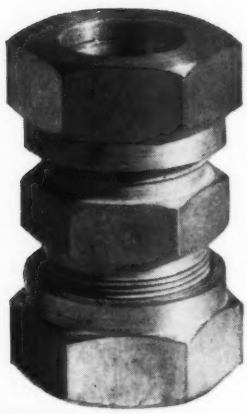
THE PERMALI GROUP

PERMALI LIMITED, Gloucester, England. Tel: 24941

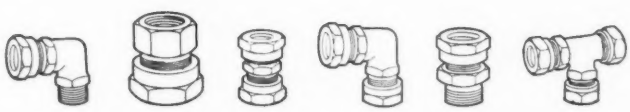
PERMALI
HYDULIGNUM
HYROC
PERMAGLASS
DIALAM
PERMAFLON
PERMACAST

Circle **No 24** on reply card for further details





Ermeto high-pressure pipe fittings work on a completely different principle from any other type of fitting.
The Ermeto joint incorporates a metallic "lock" which ensures a secure pressure tight joint under severe operating conditions. Ermeto couplings are made in mild steel, stainless steel, brass, aluminium alloy and high duty bronze. Couplings, valves, hose fittings and assemblies are available in a wide range of types and sizes. Non-standard fittings can also be produced to specific requirements.
A copy of the Ermeto catalogue illustrating the comprehensive standard range will gladly be sent on request.
Technical advice is always readily available.



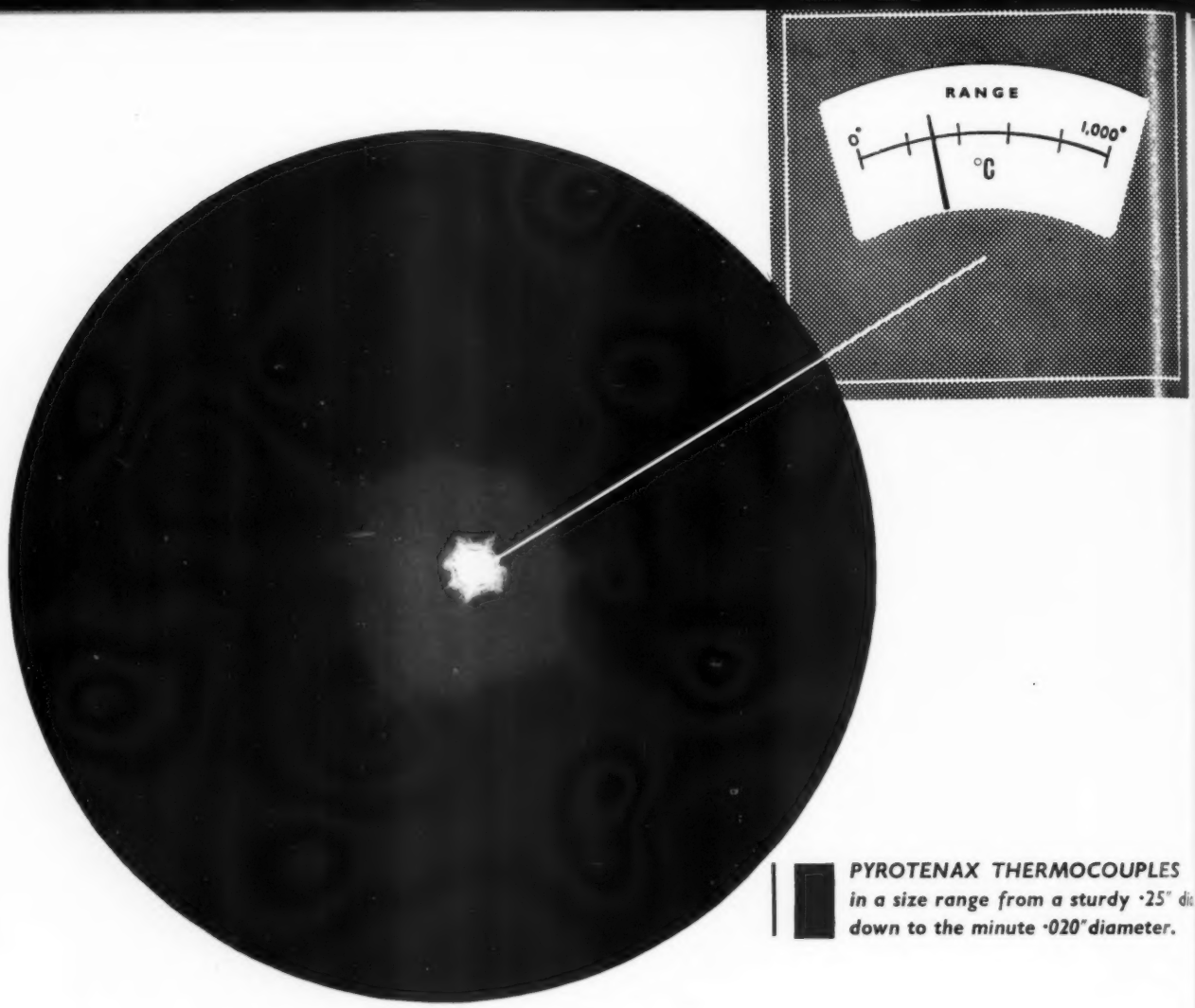
ERMETO

BRITISH ERMETO CORPORATION LTD

HARGRAVE ROAD · MAIDENHEAD · BERKS · ENGLAND · TEL: Maidenhead 5100

A member of the ALENCO Group of Companies

Circle No 25 on reply card for further details



PYROTENAX THERMOCOUPLES *in a size range from a sturdy ·25" dia down to the minute ·020" diameter.*

There is something here for every industry where temperature has to be measured—

The inherent qualities of Pyrotenax thermocouples, which were essential to the exacting requirements of nuclear power, are equally attractive to the industrial user. The temperature range is sub-zero to 1100°C., sizes ·25" down to ·020", with many alternatives of sheath and conductor metals.

- *Small overall diameter*
- *Rapid Response Rate*
- *Easily bent to shape*
- *Immune from thermal shock and mechanical damage*
- *No additional protective sheathing required*
- *Long life—inexpensively replaced*

PYROTENAX LIMITED • **HEBBURN-ON-TYNE** **Telephone : Hebburn 83-2244**

LONDON: VICtoria 3745 · **BIRMINGHAM:** Midland 2924 · **MANCHESTER:** Deansgate 3346/7
LEEDS: Leeds 27826 · **NOTTINGHAM:** Nottingham 83805 · **GLASGOW:** City 3641/2 · **CARDIFF:** 23689

PERFECTED BY EXPERIENCE
Pyrotenax
m.i. THERMOCOUPLES

GD—207

Circle **No 26** on reply card for further details

The use of the trade name Pyrotenax is exclusive to the products of this Company and its associates.

FINE STEELS and STEEL PRODUCTS

Since the foundation of the Company in 1852, over a century of progress has made the name of *Osborn* world famous for the manufacture of an extensive range of fine steels and steel products.

Manufacturing methods, blending traditional skill with modern technology ensure that these products, which include high-speed tool steels, alloy and stainless steels, castings, forgings and 'Mushet' brands engineers' tools will satisfy the most exacting standards.

SAMUEL OSBORN & CO., LIMITED
CLYDE STEEL WORKS · SHEFFIELD · ENGLAND
FINE STEELMAKERS · STEELFOUNDERS · ENGINEERS' TOOLMAKERS

SELF-SEALING COUPLINGS

for a variety of fluids

These couplings are made in a range of materials from aluminium alloy to stainless steel, some for withstanding high temperature conditions. They are completely hermetically self-sealing when disconnected but automatically provide an uninterrupted flow when re-coupled.

Our engineers, with a background of many years of experience in the design of coupling and hoses, are always ready to consider your problems and to make suitable recommendations. Leaflets giving details of self-sealing couplings and Lockheed-Avery flexible hoses, will be sent on application.

Lockheed-Avery industrial hoses, types 77 and 99, and their end fittings, are available ex stock from any of Edmunds, Walker & Co. Ltd. branches.

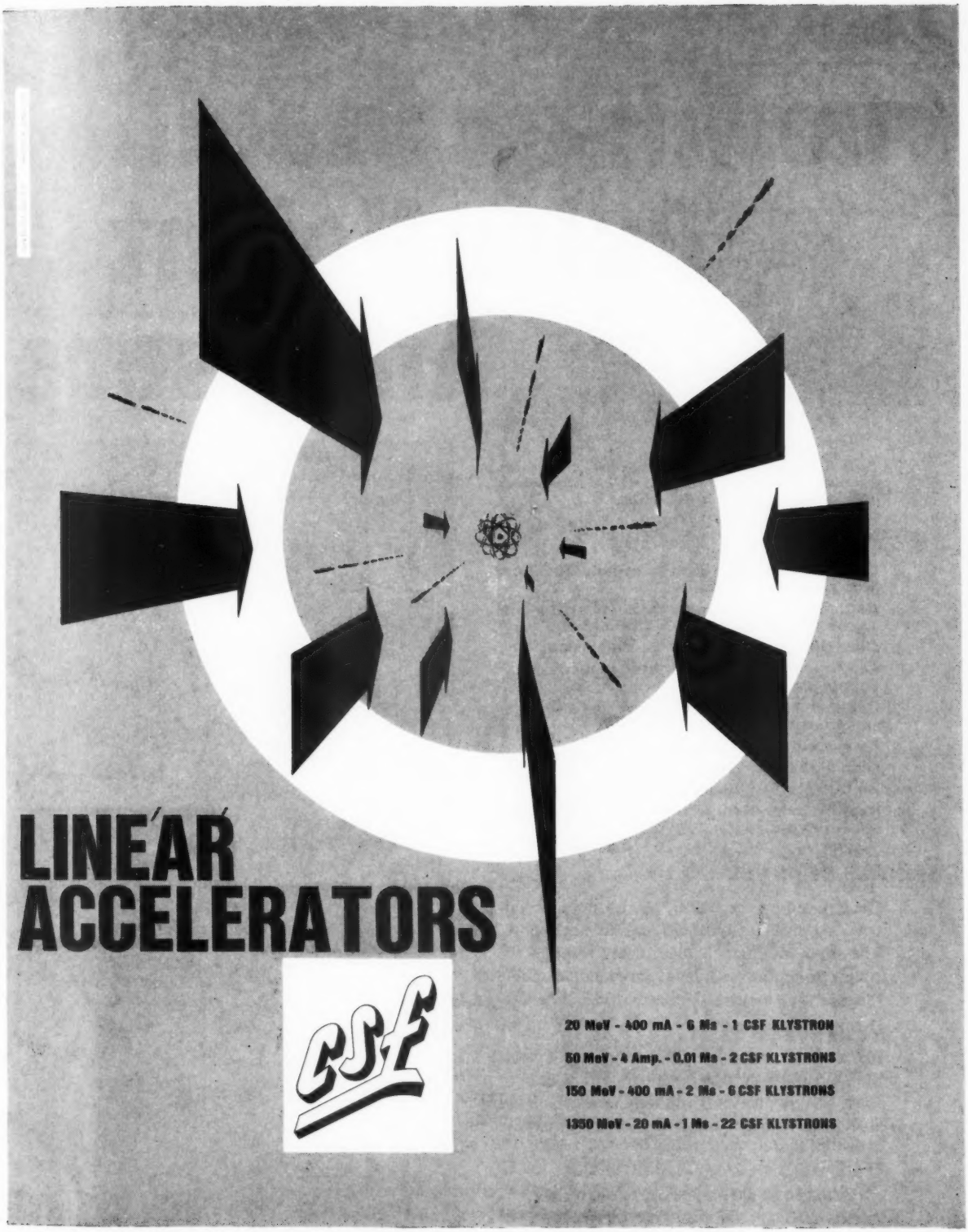
AVERY DIVISION, LOCKHEED PRECISION PRODUCTS LTD
SHAW ROAD, SPEKE, LIVERPOOL 24
***Telephone:** Hunts Cross 2121 **Telex** 62394 **Telegrams:** Lockheed Liverpool 24 Telex*

ONE OF THE AUTOMOTIVE PRODUCTS GROUP

Lockheed Avery

Circle **No 28** on reply card for further details

REGD. TRADE MARK: LOCKHEED

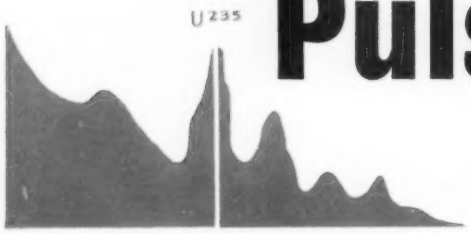

LINEAR
ACCELERATORS
CSF
20 MeV - 400 mA - 6 Ms - 1 CSF KLYSTRON
50 MeV - 4 Amp. - 0.01 Ms - 2 CSF KLYSTRONS
150 MeV - 400 mA - 2 Ms - 6 CSF KLYSTRONS
1350 MeV - 20 mA - 1 Ms - 22 CSF KLYSTRONS

DIVISION INTERNATIONALE - 79, BOULEVARD HAUSSMANN - PARIS-8 - ANJ. 84-60

RAPY

Plessey

new High Stability Pulse Height Analysers



These important contributions to gamma spectrometry technique were designed at Harwell and are manufactured under licence from the U.K.A.E.A.

99-CHANNEL

- **Channel width of 100 mV, usually requiring little pre-amplification.**
- **Adjustable back-bias permitting analysis of any 10 V band between 0.5 V and 30 V.**
- **Dead time for n^{th} channel $40+2(n+1)$ μsec.**
- **Ferrite core data storage with capacity of 2^{16} counts per channel.**
- **Decimal readout by Dekatron indicators or spectrum c.r.t. display.**
- **Extensively transistorised.**
- **High stability and linearity.**
- **Built-in test facilities.**
- **Readily converted to use as a time-of-flight spectrometer.**

SINGLE CHANNEL

Constructed on the "2000" Series unitised system. Adjustable threshold and channel width. The small variation of time delay through the circuit makes the instrument particularly suitable for operation in coincidence counting systems.

TECHNICAL SERVICE

Plessey engineers are readily available to discuss the applications of these analysers with you, or to assist on any problems you may have which are associated with gamma spectrometry generally.

PLESSEY NUCLEONICS LTD

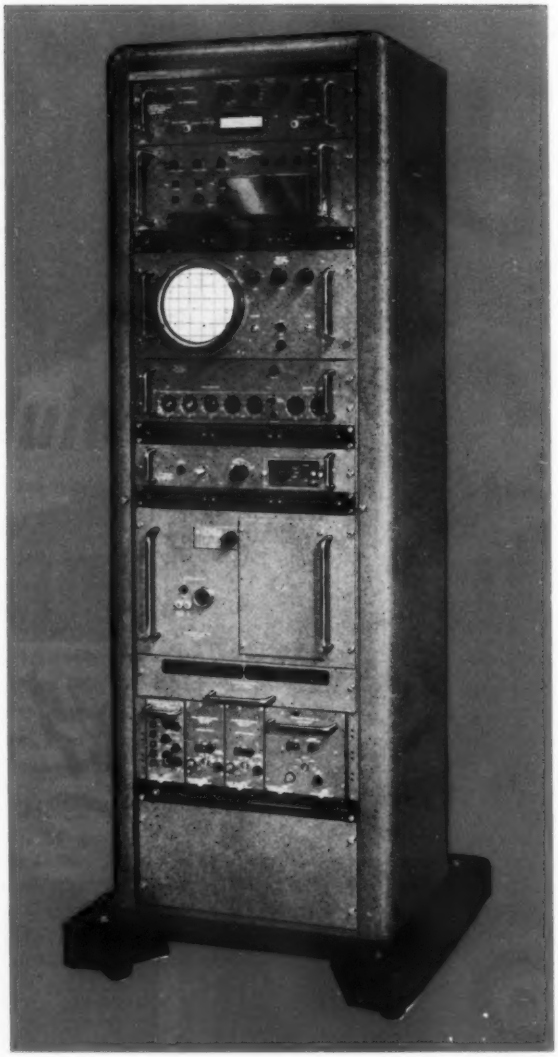
WEEDON ROAD, NORTHAMPTON

Telephone: Northampton 4966

Overseas Sales Organisation:

Plessey International Limited, Ilford, Essex

Telex: 23166 **Telephone: Ilford 3040**



PNL105

VALVES
for NUCLEAR INSTALLATIONS

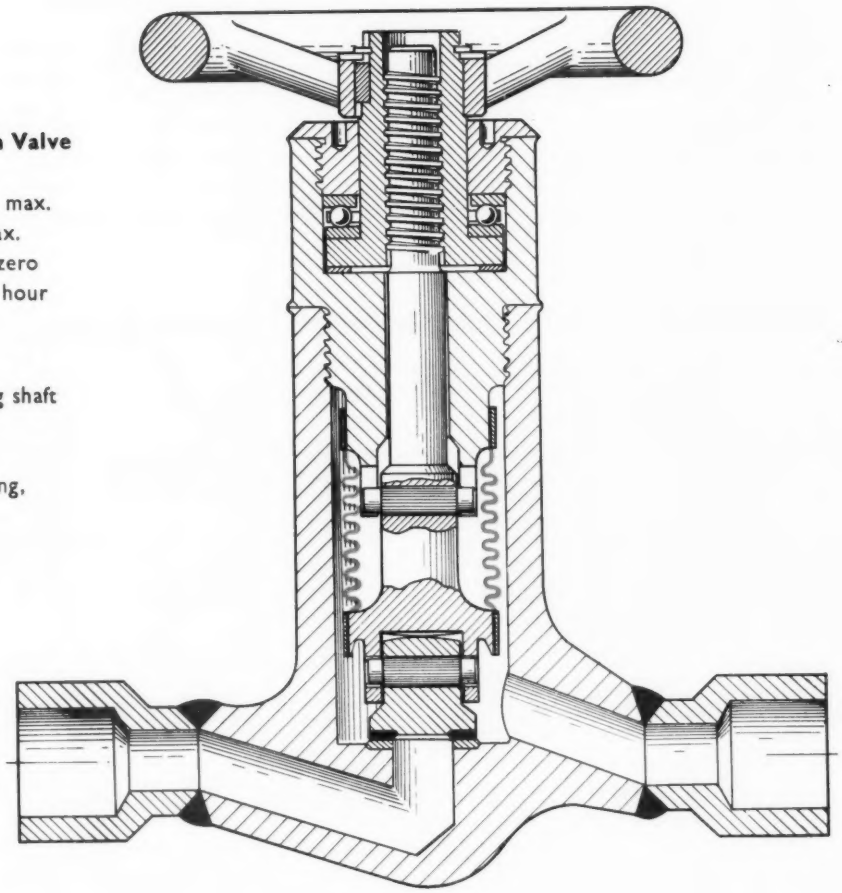
Instrument Isolation Valve

Specification

Pressure 650 p.s.i. max.
Temperature 450°C max.
Leakage to atmosphere zero across seat .001 lbs. per hour at 600 p.s.i.

Special Features

Bellows sealed operating shaft
All joints weld sealed
Back seating
Self-aligning, non-rotating, valve head
Ball thrust bearing
Chrome plated shaft



To meet the need for a satisfactory small bore isolation valve Teddington have engineered this new design now available in standard nominal bores of $\frac{1}{4}''$ and $\frac{1}{2}''$ and suitable for all fluids normally encountered in nuclear installations.

Teddington bellows sealing ensures no leak to atmosphere. The back seat prevents over movement of the bellows and provides an additional safety feature. A seal cap to replace hand wheel and prevent unauthorised operation is available if required.

See it at the Engineering, Marine Welding & Nuclear Energy Exhibition on Stand 13 Outer Row, National Hall Gallery, Olympia, 20th April—4th May.

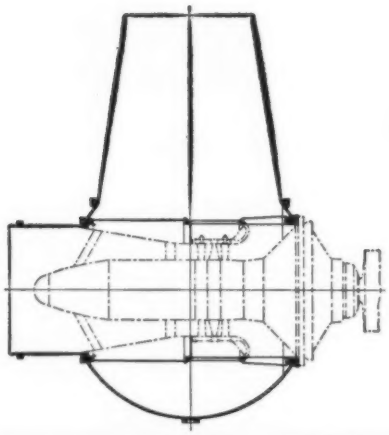
Teddington CONTROLS

TEDDINGTON AIRCRAFT CONTROLS LIMITED

NUCLEAR DIVISION: CHEAPSIDE · READING · BERKS. PHONE: READING 55235

Circle **No 31** on reply card for further details

New thinking for Trawsfynydd

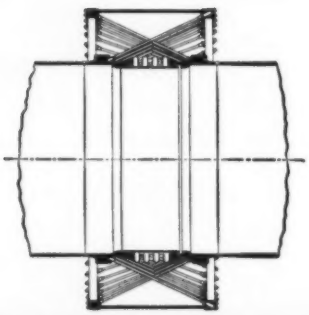


CO_2 CIRCULATORS

As every engineer knows, the thickness of plate required to contain a given pressure is halved if the vessel is spherical instead of cylindrical. It is odd—but nevertheless true—that it was not until our own engineers were confronted with the design of the CO_2 circulatory system for Trawsfynydd that the elementary principle was put into practice on large pressure pipework.
Besides halving the plate thickness spherical construction has other advantages. All welds are circular, can be prepared by machinery and are simple to X-ray.

CORNER BENDS

The same advantages follow when the same principle is applied to corner bends. In addition, the stiffeners required on cylindrical bends are eliminated. Internal tubes—not subject to pressure—provide a smooth gas flow.



EXPANSION JOINTS

It is standard practice to take up the expansion of large diameter pipework by flexing at what are essentially hinged joints. These of course have to provide restraint against axial forces—over 1,000,000 lb. in the Trawsfynydd ducting. The usual solutions, an internal metal tongue or a hinged joint are heavy, cumbersome and, moreover, flexible in one direction only. The hinge we have devised is flexible in *all* directions, by elastic straining of the high-tensile steel, restraining rods. The circumferential pressure is taken by a metal bellows, faired internally by a floating sleeve.

These ideas are not our only contribution to Trawsfynydd. As well as the complete CO_2 circulation system, we are building the whole of the generating plant, comprising steam turbo-alternators, condensing plant and feed heating systems.

RICHARDSONS, WESTGARTH & CO LTD

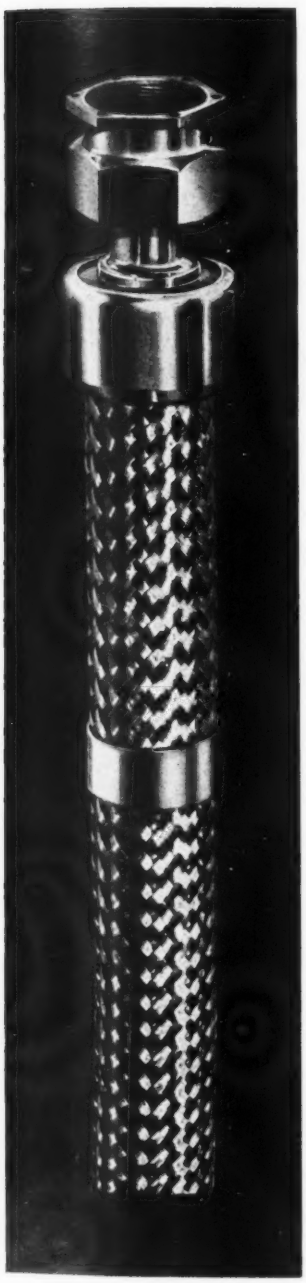
The Controlling Company of the RICHARDSONS WESTGARTH GROUP, Wallsend, Northumberland, and 58 Victoria Street, London, S.W.1

ASSOCIATED COMPANY: UNITED POWER COMPANY LTD.

RW 74

PLESSIFLEX

REGD. TRADE MARK



can take it . . .

whether 'it' is a gas or a liquid, hot or cold, corrosive or inflammable.

to wherever it's got to go...

in any of an infinite range of aeronautical, marine, chemical or nuclear applications.

safely and surely...

because, where misalignment or relative movement so demand, Plessiflex will bend, flex or bow but never, never complain. It withstands the most exacting conditions of blast or vibration, cold or heat, or high internal pressure — or all of these at once.

in many sizes

from ¼" to 8" bore. And Plessiflex may be had in various metals including stainless steel, brass, copper and Monel.

Write for Publication No. 1121

metallic hose and ducting

POWER AUXILIARIES LIMITED

Kembrey Street • Swindon • Wilts • Tel: Swindon 6211

Overseas Sales Organisation:

PLESSEY INTERNATIONAL LIMITED • Ilford • Essex • Tel: ILFord 3040

One of the Plessey *Group of Companies*

PAL 16

Circle **No 33** on reply card for further details

Essential reading for every modern engineer

Brings you right up to date on Molybdenum Disulphide lubrication with ROCOL MOLYBDENISED LUBRICANTS. Brief, factual and complete—specially written and designed for fast reading. Contains over 60 actual case histories.

WRITE TODAY FOR YOUR FREE COPY!

ROCOL LIMITED Dept. S

GENERAL BUILDINGS, ALDWYCH, LONDON W.C.2. Tel: HOLborn 1985

ROCOL HOUSE, SWILLINGTON, Near LEEDS. Tel: Garforth 2261

7862

RIO TINTO

Rio Tinto, producers of uranium and thorium, will play an important part in the future industrial use of nuclear power through the following companies:

Rio Algom Mines Limited, CANADA has amalgamated the four Canadian uranium mining companies under Rio Tinto's management, to form the largest uranium producing company in the world.

Mary Kathleen Uranium Ltd., AUSTRALIA managed by Rio Tinto in Australia, is now in full production and supplying uranium for Britain's nuclear power stations.

Rio Tinto Dow Limited, CANADA Rio Tinto and the Dow Chemical Company of Canada are collaborating in uranium processing and producing thorium as a by-product of uranium.

Thorium Limited, UNITED KINGDOM owned by Rio Tinto and Dow Chemie A.G. processes crude thorium materials and markets a variety of refined thorium and rare earth compounds.

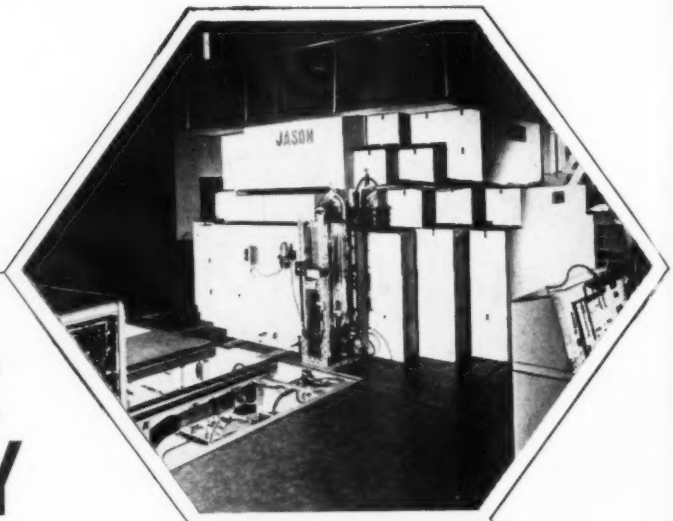
Nukem–Nuklear-Chemie und-Metallurgie G.m.b.H., GERMANY has been formed by Deutsche Gold-und Silber- Scheideanstalt (Degussa), Rio Tinto, Metallgesellschaft and Mallinckrodt Chemical Works to manufacture nuclear fuel materials and fuel elements.

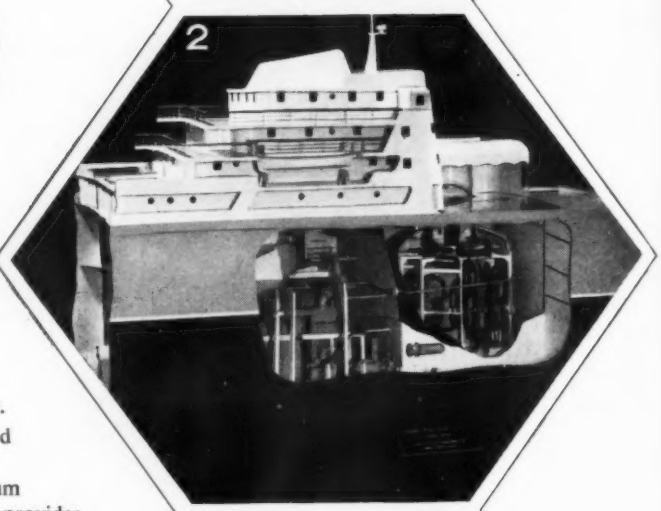
Austro-Chematom Kernbrennstoff G.m.b.H., AUSTRIA formed by the Osterreichische Stickstoffwerke A.G. in association with Rio Tinto and Degussa to manufacture nuclear fuel materials and fuel elements.

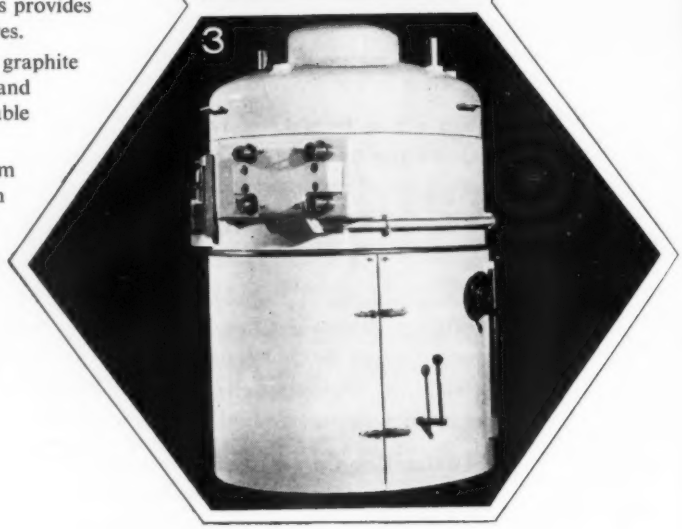
RIO TINTO MANAGEMENT SERVICES (U.K.) LIMITED
BARRINGTON HOUSE, 59 GRESHAM STREET, LONDON E.C.2.

Circle **No 35** on reply card for further details

HAWKER SIDDELEY NUCLEAR POWER







A Comprehensive Research, Design and Manufacturing Service in Nuclear Engineering.

Designers of Organic Moderated reactors for small power stations and ship propulsion.

The recent acquisition of Nuclear Engineering Limited adds to the Jason range of research and training reactors a wide choice of standard Cobalt and Caesium irradiation units. Combination of these two products provides the basic equipment for small nuclear research centres.

H.S.N.P. is now producing SUPERGRAPH, a new graphite based material. Twice as strong as normal graphite and a million times less permeable. It has many remarkable applications in general engineering.

High temperature controlled atmosphere and vacuum furnaces are also being manufactured in conjunction with Spembly Limited of the Harper Group.

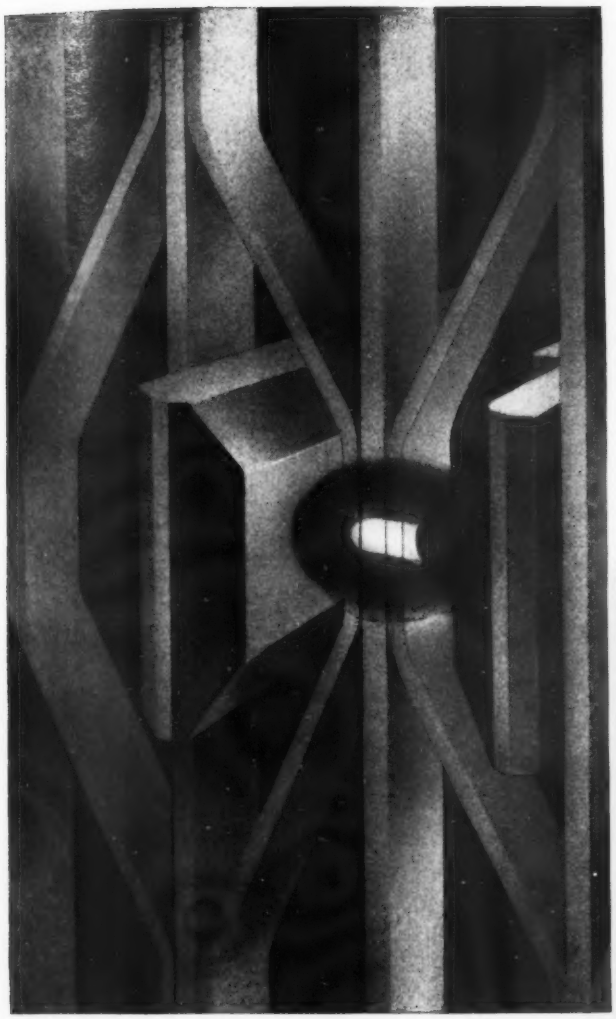
The factory, at West Howe—Dorset, is under the management of H.S.N.P. for The United Kingdom Atomic Energy Authority. Other activities include design and manufacture of specialised prototype and test equipment.

1. JASON Research & Training Reactor.
2. First British Organic Moderated Reactor system proposed for marine propulsion.
3. Automatron self-contained gamma irradiation unit.

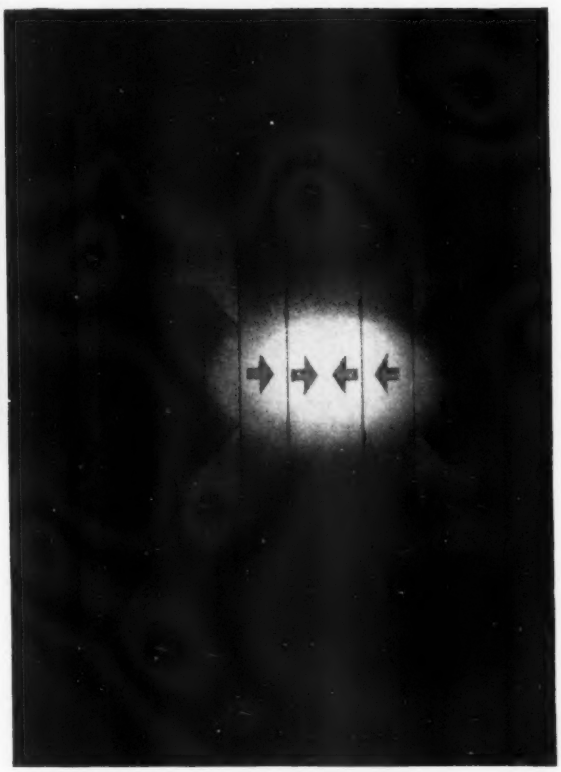
For consultation, research, development or production, write to:

HAWKER SIDDELEY NUCLEAR POWER COMPANY LIMITED or NUCLEAR ENGINEERING LIMITED

MEMBER COMPANIES OF THE HAWKER SIDDELEY GROUP, SUTTON LANE, LANGLEY, BUCKINGHAMSHIRE, ENGLAND



the unique SAFETREAD resistance welding method cuts corrosion



"Safetread" steel flooring is *homogeneously resistance welded under pressure*—thus closing the grain of the material and providing a highly corrosion-resistant joint of great strength. "Safetread" floors installed for many years under rigorous conditions show that the least corrosion has taken place at the point of welding. Welded through the neutral axis of the main bar, maximum strength and lateral stability is also gained.

Engineers everywhere specify "Safetread"—its unique design and construction give greatest strength and rigidity with a minimum of weight which enables valuable economies to be effected in supporting members. "Safetread" is tailor-made to your specification no matter how intricate the layout. WRITE TO-DAY for the "Safetread" catalogue—it's a mine of information including deflection tables, safe load tables, etc., a valuable work of reference for the man with a flooring problem.

SAFETREAD WELDED STEEL FLOORING

ALLAN KENNEDY & CO. LTD., MARITIME STREET, STOCKTON ON TEES

Tel: Stockton 65464 (4 lines) Grams: 'Grating' Stockton on Tees. London Office: Abford House, Wilton Road, S.W.1. Tel: VICtoria 2539

P4895

Circle No 37 on reply card for further details

NEWALL'S COLD SWAGING PROCESS IN THE NUCLEAR FIELD....

A P Newall & Co Ltd have been pioneers in the manufacture of swaged studs and bolts. The firm was actually associated with early work in the atomic field when certain swaging operations were required in the planning of Harwell.

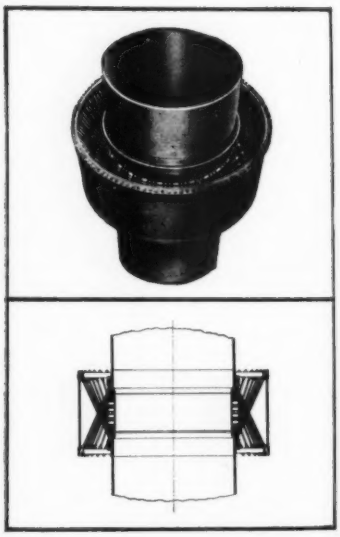
One recent application of Newall's cold swaging process was in the manufacture of high tensile steel bars for use in the Bellows Restraint Mechanism illustrated (right). In this assembly, the considerable operating pressures are transmitted entirely by the tension bars, which had to possess the following qualities:

(*a*) They had to provide a high degree of flexibility.

(*b*) A uniform tensile strength of approx. 75 tons throughout their length was required.

(*c*) They had to have a surface completely free from machining marks.

These bars, after extensive experiments and tests, have been produced and incorporated in the mechanism. In use, they show "extremely high fatigue strength in the high deflection range".



Bellows Restraint Mechanism, designed by Richardsons, Westgarth & Co Ltd, for the Trawsfynydd Nuclear Power Station.

A.P.NEWALL

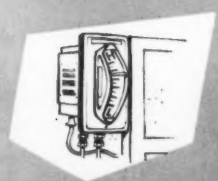
AND COMPANY LIMITED
POSSILPARK · GLASGOW N.2
Also at London and Birmingham

Circle No 38 on reply card for further details

Installation's no problem. You need no special foundations, no plinths, no bolting down—just a flat floor that will bear 6 cwt./sq. ft. —the I.C.I. tank is supplied as a self-contained unit complete with chassis and, if necessary, can be easily moved.

If ground-space is scarce, the tank can be sited up to 20 ft. above floor-level.

Easy to operate — CO_2 is available at the opening of a valve, and the tank can be refilled without interrupting supply.



Easy to maintain and service — all parts readily accessible; for instance, the contents gauge can be serviced without emptying the tank.

I.C.I.'s Technical Service staff will advise on problems of CO_2 piping and metering. Tanks of larger capacity can be designed to customer's requirements.

ICI

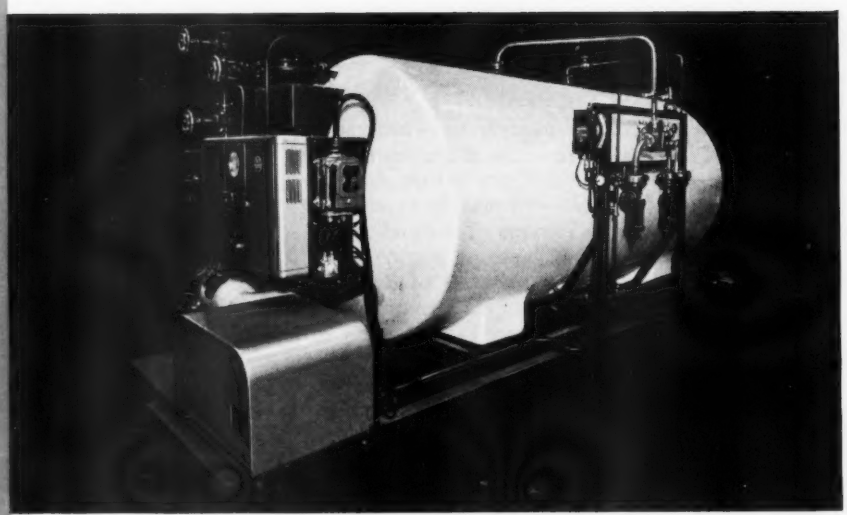
DK.336

Even if you buy as little as 30 tons of CO_2 a year, the cheapest way of buying it is in bulk—and the best storage container is I.C.I.'s 5-ton liquid CO_2 tank. You'll need only 6 or 7 deliveries a year, and the tank will pay for itself in a very short time.

There's no problem in installing I.C.I.'s 5-ton liquid CO_2 tank—in fact, it can be delivered one day and in use the next. And I.C.I.'s Technical Service staff will supervise its start-up.

You'll find that for you, as for many other users, the I.C.I. liquid CO_2 tank will mean extra profit.

I.C.I.'s LIQUID CO_2 TANK MEANS TONS OF ECONOMY



If you'd like to discuss the economics of bulk delivery, or the installation of I.C.I.'s tank at your works—or if you'd simply like to read I.C.I.'s booklet on liquid CO_2 in bulk, get in touch with Imperial Chemical Industries Ltd., London, S.W.1.

Circle No 39 on reply card for further details

LEAKAGE

can

be stopped

with

flexibox

mechanical seals

Positive prevention of gland leakage is infinitely better than trying to cure its effects. Potentially dangerous leakage from pumps, blowers, compressors and other rotary shaft equipment can be efficiently prevented by fitting mechanical face-type gland seals. Our wide experience of sealing equipment handling all kinds of fluids – including radioactive materials – is at your disposal. If you haven't already got our design data on your files we suggest you write now to:—

FLEXIBOX LIMITED

A MEMBER OF THE M.O.R. GROUP OF COMPANIES

Agents and representatives in all parts of the world
Patents granted or applied for in all principal countries

Head Office and Main Works:
NASH ROAD · TRAFFORD PARK · MANCHESTER 17
Telephone: Trafford Park 1477 Telegrams: Flexibox Manchester Telex
Branch Factory: BALLYMENA · CO ANTRIM · NORTHERN IRELAND
Telephone: Ballymena 6424 Telegrams: Flexibox Ballymena Telex
London Office: 76 JERMYN STREET · LONDON S.W.1
Telephone: Whitehall 8411 Telegrams: Flexibox London Telex

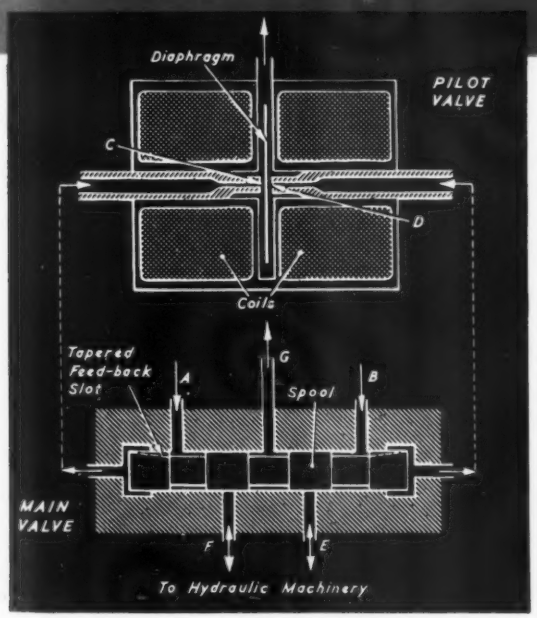
In the U.S.A., and Japan: SEALOL INC. PROVIDENCE RHODE ISLAND

In Germany: FLEXIBOX G.m.b.H. SCHIELESTRASSE 45 FRANKFURT/MAIN-OST

In France: FLEXIBOX S.A. 38 RUE DE TREVISE PARIS 9

TYPE A·W·E 144/5 ELECTRO-HYDRAULIC SERVO VALVE

This electro-hydraulic servo valve, developed by Armstrong Whitworth from their successful aircraft unit, can be used to control a wide range of hydraulic machinery and is particularly suited to process control systems. The valve utilizes hydraulic rather than electrical power amplifications and has a remarkably high power gain. A diaphragm, clamped around its periphery by two coil housings, is used to control the power — instead of the usual torquemotor — and the valve is therefore not susceptible to vibration effects.



The valve — see diagram — consists of a main valve and a pilot valve. The main valve is supplied with pressure oil through ports A and B. When the spool is in the central position — as shown — the oil escapes through the tapered slots to the opposed jets C and D in the pilot valve and impinges on each side of the diaphragm. The two coils can be energised to attract the diaphragm towards one or other of the jets. If the signal to the right hand coil is the stronger, the diaphragm will flex to the right, restricting the flow from the right hand jet and thus increasing the pressure in that line. Similarly, the pressure in the left hand line is reduced. This pressure difference is transmitted to the main valve and causes the spool to move to the left until the resultant decrease in discharge area of the tapered slot at the right hand end of the spool and the increase in that at the left cause equilibrium to be restored. The displacement of the spool uncovers ports E and F, thus opening pressure and return lines to the hydraulic machinery.

ARMSTRONG WHITWORTH EQUIPMENT HUCCLECOTE, GLOUCESTER · TELE: GLO 66781

SIR G. W. ARMSTRONG WHITWORTH AIRCRAFT LTD., A MEMBER OF THE HAWKER SIDDELEY GROUP

Circle No 41 on reply card for further details

FOSTER WHEELER

ANNOUNCE THEIR REMOVAL

TO NEW

PREMISES

The London address of the world-wide Foster Wheeler organisation is now :—

FOSTER WHEELER HOUSE, CHAPEL STREET, N.W.1.

Increasing commitments have necessitated the expansion of all departments embracing the design, engineering, fabrication and construction of :—

Single units and complete refineries for the oil and chemical industries.

Land and marine boilers and ancillary equipment for power generation.

Complete reactor coolant circuitry for nuclear power.

Foster Wheeler also offer every facility for research and development including co-operation on heat transfer, fluid flow and kindred problems of nuclear power.

FW

FOSTER WHEELER LIMITED

FOSTER WHEELER HOUSE, CHAPEL STREET, LONDON NW1. Telephone PADdington 7221

THIS one raised the roof

Fabrications in unusual shapes and sizes are Marston's speciality — fabrications like this aluminium brass end seal for a heat-exchanger at the National Gas Turbine Establishment.* It was so big that we had to remove part of the roof in one of our erecting shops — but that kind of thing is all in the day's work for us. If you're contemplating engineering, chemical petroleum or nuclear power plant that calls for components to unusual specifications, consult us at the design stage: our experts can contribute much to the smooth, speedy and economical execution of your plans.

Process plant · Bursting discs
Pressure vessels · Heat-exchangers
Pipework · Special-purpose machines
in aluminium, titanium and other non-ferrous metals.

*Made for :—National Gas Turbine Establishment.

ICI

MARSTON EXCELSIOR LIMITED
A subsidiary of Imperial Chemical Industries Limited
Fordhouses, Wolverhampton
MAR.281

product of precision

Precision engineering
and the use of high quality
(Air Board approved)
material ensure the
constant reliability of
ME universal ball joints.

Write today
for catalogue

ME

The Mollart Engineering Co Ltd

KINGSTON BY-PASS SURBITON SURREY

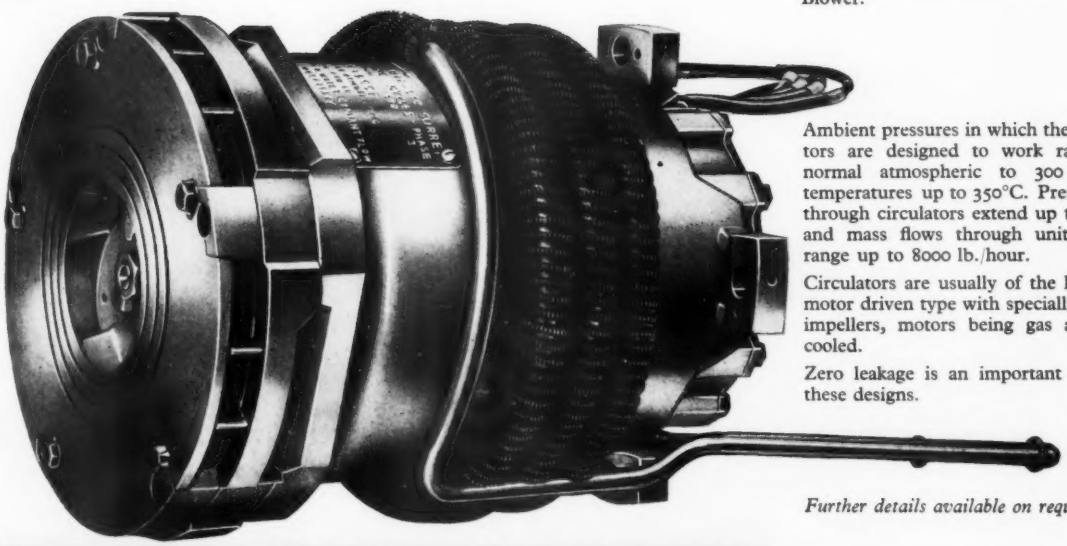
Telephone: Elmbridge 0033 (5 lines) Telegrams: Precision Surbiton

P5339

"PLANNAIR" GAS CIRCULATION BLOWERS FOR NUCLEAR PROJECTS

Carbon dioxide circulator for fuel element cluster, here illustrated, provides for reliable and efficient cooling of nuclear reactors. The blower, with its 11,500 r.p.m. motor (200V 400 c/s supply), is sealed within a long pressure vessel at the opposite end to which the nuclear reaction occurs. CO_2 circulates through the tube at 285 p.s.i. A and 95°C. The blower output is 6300 lb./hour at 7.5 p.s.i. pressure differential. A secondary radial impeller gives a cooling gas circuit via a demineralised water heat exchanger coil which keeps the motor operating at below 75°C.

This is but one of several gas circulating blowers which Plannair have designed for various nuclear projects. These include a Leaky Cartridge Test Rig Air-Blower, a Sodium Loop-Nitrogen Circulator, a Helium Circulator, Air Circulators and a Nitrogen Circulator, CO_2 circulator for Fuel Element Cluster Irradiation Test Rig, Burst Fuel Element Test Rig Air-Blower.

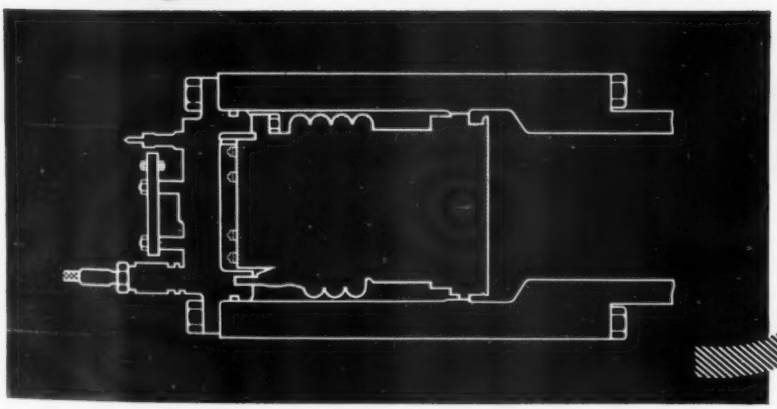


Ambient pressures in which these circulators are designed to work range from normal atmospheric to 300 p.s.i. at temperatures up to 350°C. Pressure rises through circulators extend up to 30 p.s.i. and mass flows through units cover a range up to 8000 lb./hour.

Circulators are usually of the high speed motor driven type with specially designed impellers, motors being gas and liquid cooled.

Zero leakage is an important feature of these designs.

Further details available on request.



PLANNAIR

PLANNAIR LIMITED

Windfield House • Epsom Road

Leatherhead • Surrey

Tel: Leatherhead 4091/3, 2231

PLA39

Shell demonstration

Two clean, bright pennies are placed in beakers of oil, of equal performance level, one Shell Garia Oil 21, the other a conventional cutting oil containing sulphurised additives. After three hours at room temperature one penny is still bright and stain-free, the other heavily stained with black copper sulphide. The bright penny is from the beaker containing Shell Garia Oil 21, the blackened one from that containing the conventional oil. While these were just pennies they could have been bronze bushes in your machine tools—stained in less than half a shift. Sulphur is essential in heavy-duty cutting oils. Special additives in Shell Cutting Oils protect your machine tools and yet allow the sulphur to do its job. *Write for the book "Selecting Your Cutting Oils" to Lubricants Department, Shell-Mex House, London, W.C.2.*

DROMUS . . . PELLA . . . MACRON . . . GARIA

SHELL

SHELL CUTTING OILS

Nuclear Power
REACTORS MATERIALS INSTRUMENTATION PROCESSES IRRADIATION

MAY 1961 VOLUME 6 NUMBER 61

VIEWPOINTS *letters to the Editor*

Jason under control

SIR: I should like to thank Mr Bobbin (*Viewpoints*, March) for pointing out a typographical error in my article regarding the procedure for measuring differential control rod worth in JASON. After measurement of the flux doubling time (see p. 105, differential control rod worth, paras. 3 and 6) the reactor is made critical by inserting the other control rod, not withdrawing it. Use of the term 'critical' should be sufficient to prevent any misunderstanding in this instance.

As JASON is a water moderated reactor I was interested in the writer's statement that the method is only suitable for graphite moderated reactors. In our discussions with the UKAEA prior to installing this reactor, they favoured this procedure for measurement of control rod worth. Since then we have used it successfully on several JASON type reactors and the results have compared favourably with those obtained from rod drop measurements. I am interested to know whether there has been an official change in attitude with regard to this procedure on the part of the UKAEA?

I have not found anybody familiar with the term 'True Operational Configuration' as applied to control rods in this type of reactor, as they are normally positioned to suit the experiment being performed. The shape of the differential and integral rod worth curves are, for all practical purposes, unaffected by their relative positions, one to the other. Perhaps your correspondent could furnish more concise information on this subject.

B. W. EMMERSON
REACTOR SUPERVISOR
Hawker Siddeley Nuclear Power Co, Ltd

German industry compared

SIR: We note with some surprise in the March edition of *Nuclear Power* the announcement under your New Product Survey that 'Bleiwerk G. Rohr can now provide rolled lead and lead sheets in widths up to 10 ft and in unit weights up to 15,432 lbs' (Item 215).

The British Lead Industry has been able to supply rolled lead and lead sheets in widths up to 12 ft with a maximum weight limit of some 26,000 lbs for a great many years.

We feel that in view of the circulation of your Journal among companies using such materials as lead sheet, but with no great knowledge of the products of the British Lead Industry, the unintentional suggestion that the German capabilities are at all exceptional is rather unfortunate.

We feel sure you will agree with us that this information on the capabilities of the British Lead Industry would be of value to your readers.

Your co-operation in this matter would be very much appreciated.

C. H. KNIGHT
TECHNICAL SECRETARY
Lead Development Association

Off-load fuel handling

SIR: The announcement that a Calder reactor has operated at full belt for 350 days out of 365 (*Worldview*, March) should not go unremarked. Apart from all the other considerations, it is a notable achievement for the Springfields factory to have produced a batch of many thousand fuel elements without a single dud.

Could this result affect our ideas about changing fuel on load in the industrial reactors? If fuel elements are capable of reaching their design irradiation without random failures due to manufacturing defects, why bother to change them on-load? No doubt machinery can be, and has been, developed which is equal to the fearsome task of entering a reactor running at full pressure and temperature and safely extracting fuel. But it must be extremely expensive machinery to build, operate and maintain; and surely we should admit that with all the care possible, off-load fuel handling must be safer.

One would deliberately shut down on a fixed date in order to unload and recharge the reactor completely. This would not necessarily mean any loss in availability, as many parts of the plant will have to be overhauled or inspected at least once a year. Of course, thousands of elements would be discharged with plenty of life still left in them. But if the target mean irradiation has been achieved the value in squeezing out a bit more burn-up is marginal; in any case, one can never achieve the ideal of discharging every element just before it bursts, even with on-load gear.

The CEGB might consider ordering their next nuclear stations without on-load charge/discharge gear (which will knock off a few more pounds per kilowatt) while still retaining standpipes which could accept such machines later if they are found to be desirable. We are only on the threshold of learning about the behaviour of the industrial fuel elements, there is not much point in ordering equipment which might not be fully used.

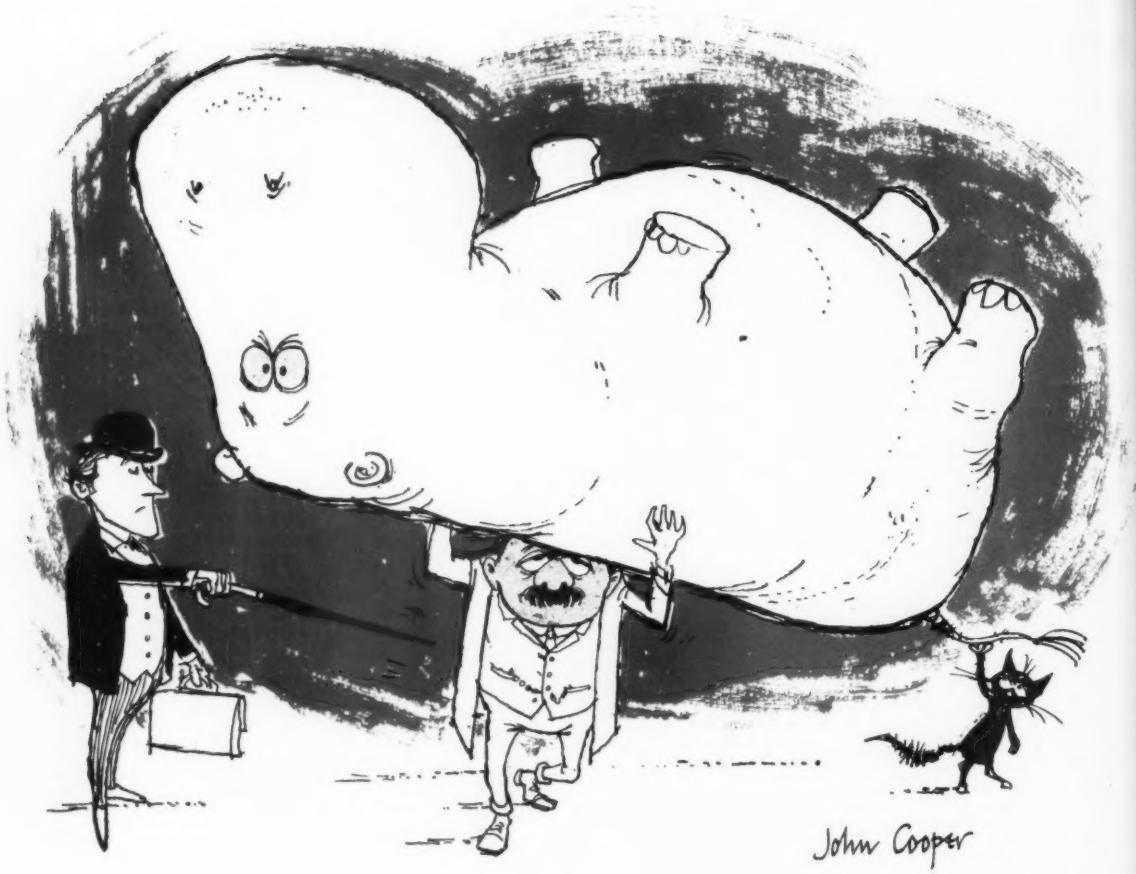
ROBIN F. W. GUARD
Kennedy & Donkin

B.S. abbreviations

SIR: First of all may I say how I enjoyed your Dungeness issue, it takes its place as a valuable contribution to the technical literature. But I was puzzled at first by the use of 'lbf' throughout. I understand now that this abbreviation follows the British Standard recommendation made last October to distinguish between units of mass and the weight under standard gravity as a unit of force. Is this really necessary? We have got along very nicely with 'psi' for a long time, and I can just about live with 'lb/in²', but not another change, please!

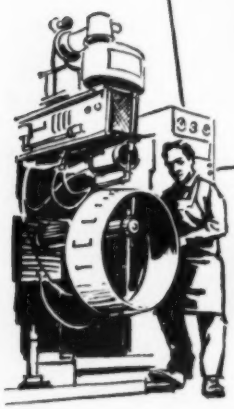
L. O. GITTINGS
Northwich

Have you filled in your readership survey form yet ? This will be found facing page 51 and you are asked, in your own interest, to complete and return the form so that we can keep in closer touch with your views and preferences.



Nothing is too difficult for us to Handle!

"Have Welding Apparatus will travel"



Modestly . . . we believe that we can weld any material known to man, beast or hippopotamus . . .

The equipment in our welding and fabrication shops is the latest and most up-to-date in the country; this, combined with the experience and skill of our craftsmen, enables us to offer a service second to none and to produce goods of unsurpassed quality, on time and at economic prices.

If YOU have a problem and it concerns sheet metal . . . contact the SPECIALISTS

VANDYKE ENGINEERING LTD

for delivery, value and versatility

PINNACLES HARLOW ESSEX HARLOW (Essex) 24652 (P.A.B.X.)

OPINION

Nuclear ship indecision

IF THE SIGNS and sounds made in and out of Parliament are any guide, there is little hope left that this country will soon start building a nuclear-powered ship. Shortly before Parliament rose for the Easter recess, the Minister of Transport, Mr Ernest Marples, dropped a broad hint to this effect; he made it clear that the Government would think more than twice about encouraging uneconomic projects. One could cite examples of official spending to make this an extremely tenuous argument but undoubtedly the attitude stems from severe Backbench criticism of the Government's committing itself to spend some £18 million on a new Cunard liner. These Conservative Backbenchers are opposed to further state aid for industry and even more to a nuclear project which is said to be uneconomic. Personalities also play their part in this. It is no secret that the Minister of Transport does not get on as well as he should with some of his Cabinet colleagues; they may well see in this 'nuclear white elephant' a chance to hold back his political rise.

Whatever the reasons, the delay in coming to a decision—so typical of authority where nuclear power is concerned—is something that reflects sadly on the Government. The first moves towards feasibility studies on nuclear ship propulsion plant were taken nearly three years ago—before the autumn of 1958—by the UKAEA and British industry. This was in response to enquiries by tanker fleet owners on the status of marine reactor technology. At the end of 1958, the Admiralty sought proposals for a surface ship. An Admiralty committee, later called the Galbraith Committee, then set up a technical sub-committee to study proposals for a large tanker with a 60MW reactor that were submitted by seven groups. The outcome of the study was the decision to invite five firms to submit tenders based upon either the BWR or the OMR. Still awaited is the decision as to whether any of these proposals is attractive enough to proceed with.

Meanwhile, British industry is getting restless and one of the five firms involved in the tenders is closing down (see *Worldview*, this issue). In contrast, work elsewhere is progressing rapidly; the American *Savannah* is due for her maiden voyage shortly and the Soviet *Lenin* has been operating in the Arctic regions for some months. Much of the activity in Europe is centred in Germany where, at a cost of £1.37 million, half of which is being met by the Federal Government, four design studies for a BWR, PWR, GCR and OMR are in progress and due for completion this year. Tenders are also being considered by the non-profit making Hamburg company GKSS for the construction of a 22,000 ton experimental vessel.

The French have an AGR project for a land based prototype which is to cost some £3 million over a three year period. All that is needed to start is final Government approval on finance. In Italy, the two firms, Fiat and Ansaldo, have signed a two year development contract for work on a PWR with the National Committee for Nuclear Energy. This will cost £1 million—the amount spent by British industry on ship tenders so far—and may be followed by a construction programme. Information studies and research and development work are being carried out in Denmark, the Netherlands, Norway, Sweden and Japan. The last country has an information exchange agreement with the GKSS of Hamburg.

Generally, it is agreed that it will be some ten years before an economic nuclear merchant ship is built. But the Government should bear in mind that previous forecasts about nuclear power have gone wrong. The Minister of Transport should also realise that the application of nuclear power to merchant ships is one of the more economically promising applications. A start, even a modest one, should be made without any more of this deadening procrastination. If the Government thinks that private enterprise should not be subsidized to build a nuclear ship as well as a Cunard liner, then let the former be handled by the Admiralty. Alternatively, if current reactor concepts offer no future hope of being economically viable, then an intensive search for radically new concepts must begin—and begin very soon.

The problem can, of course, be tackled at an international level, following the lead taken by Euratom and the European Nuclear Energy Agency. Whilst final agreement has yet to be reached on Euratom's participation in the French ship project, it has been committed to bear 40 per cent of the total cost of the German GKSS reactor and probably the same amount for the Italian tanker study. Joint European action on a nuclear merchant ship is being considered by two ENEA working parties who will report later this year. If the UK is unwilling to proceed with its own programme on the grounds of cost—and abandon her long history of maritime achievement—then it is reasonable to lend active support to the move towards a joint European project.

CASTROL INDUSTRIAL OILS

Castrol Industrial Oils chosen for Dungeness Nuclear Power Station

Sir Robert McAlpine & Sons Ltd., who are constructing Dungeness Nuclear Power Station, use Castrol Industrial Oils in all their equipment.

The Power Station is designed for a net output of 550 Mega watts and will be lubricated by Castrol Radiation Resistant as well as conventional lubricants.

Castrol INDUSTRIAL OILS

CASTROL INDUSTRIAL LIMITED, CASTROL HOUSE, MARYLEBONE ROAD, LONDON N.W.1.

WORLDVIEW

the month in atomic energy

EUROPE

Hawker Siddeley closes Langley plant

London Many of the staff, even top executives, were taken by surprise at the sudden decision to gradually close down the Langley factory of the Hawker Siddeley Nuclear Power Company. This means the virtual withdrawal of the Hawker Siddeley Group from the nuclear development field. The firm's Bournemouth factory, with its engineering facilities, is not affected.

Officially, the closedown was forced 'upon the Group as a result of the uneconomic trend which has developed in this type of industry ', according to an official spokesman. However, there is speculation that the Group, though strong in assets, is short of ready capital and that its finances are under strain. This situation is said to arise from the purchase of the Brush Group some years ago, the cost of advanced aircraft projects and the declining market for civil and military aircraft.

The Langley pruning is looked upon as a probable first stage in the reshaping of the Hawker Group which is thought to be too cumbersome in its present form. The cut will save an estimated £250,000 yearly but the unprofitability of the factory is thought to be only one reason for its closure. The site is an attractive one and visits by Ford representatives have given rise to speculation that the Ford Motor Company will make a bid for it. Already, Ford's Commercial Division has expanded and purchased land nearby.

Meanwhile, all commitments undertaken by HSNPC will be fulfilled. ' The shutdown will be affected progressively during the next few months,' the official statement says. ' Naturally, we regret having to take this step but there is no alternative. Some of the work may be transferred to other Hawker Siddeley factories '. The Group spokesman emphasised that the decision to close did not affect in any way, work by other Hawker companies for the Atomic Energy Authority.

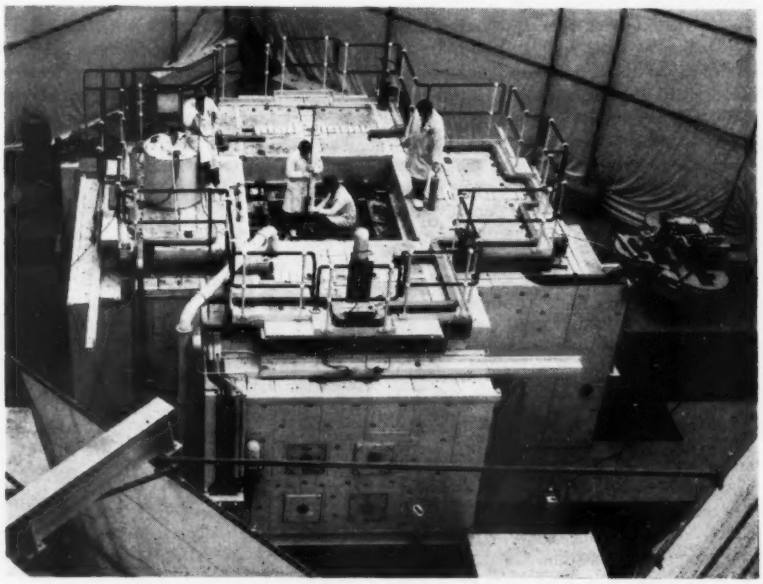
Though there were rumours a few days before the decision was announced, the notice to close is said to have come suddenly, without even the chief executive having much warning. It comes at a time when the demand from British universities for the JASON research reactor looks more promising than ever. Queen Mary College, London, is still to receive its reactor (when an official decision is finally made) and inquiries have also been received from the Royal Naval College, Greenwich, the Northern Universities and from Glasgow University.

The company, *Nuclear Power* understands, also had plans for a straight slab 3-5 kW reactor with a 10^{11} flux. This retains the experimental flexibility of the JASON while requiring no coolant. Its fuel charge was less than 3 kg of U235 and at a cost of £30,000 it was aimed at the Colleges of Advanced Technology. A prototype was to be built in August.

During its five years work in nuclear research and development, mainly on liquid cooled systems, research reactors and specially prepared graphite, the company had built up a solid reputation. It had developed a graphite impregnation pilot plant which had a successful run at around design temperature recently and fuel cans for both the DRAGON project and for General Dynamics. These have undergone long irradiation tests. In addition, a small team of chemical engineers was working on fuel cell development.

But the loss that will be felt most of all in the nuclear industry is the break-up of the OMR design team. This dissolution will mean that the £130,000 spent on preparing OMR ship tenders for the Government will have been in vain.

• **W. Germany** The Johannes Gutenberg university, Mainz is to buy a 30 kWt TRIGA Mark II reactor for 1962 operation.



Shown during the initial approach to criticality is the 10 kW NESTOR reactor which went into operation at the AEE Establishment, Winfrith, recently. Loading of a highly enriched uranium fuel element is taking place. NESTOR is designed to act as a source of neutrons for sub-critical assemblies

WORLDVIEW

Research reactor export policy criticized

London Subsidized American export sales of research reactors and lack of similar official help for British firms was commented upon by Mr L. G. Burnard, chief engineer of Vickers-Armstrong (South Marston) Ltd. He was speaking at a symposium organized by the Pharmaceutical Society of Great Britain and Smith and Nephew Research Ltd at the School of Pharmacy, University of London.

He pointed out that although the US officially helped in the sale of research reactors, British manufacturers, who had been asked by the Government to put every effort into the export drive, did not receive any help. The Americans were fully prepared to subsidize and in many cases, ' to make a free loan of the fuels necessary for the operation of a reactor'. No such help was given to British industries.

On the price of cobalt-60, Mr Burnard said that as the control, manufacture and distribution of isotopes was a Government monopoly, it was not possible to discover whether the quoted cobalt-60 price was a factual economic one. Evidence suggested that it should be much cheaper. If the price were maintained at its present level, sterilization by gamma-radiation of surgical and medical products would never be much more than a laboratory technique. There were many export markets open and the cost of cobalt-60 would be the major limiting factor in sale. There was an even greater scope for exporting sterile medical products. With more civil stations coming into operation, cobalt-60 should become even cheaper.

Mr Burnard said he thought it would have been more profitable to sell large quantities of isotopes at a reasonable price rather than to sell small amounts at an arbitrarily high figure. A timely reduction in price would give an impetus to export sales of large engineering equipment necessary for irradiation techniques and to the adoption of this safe method of obtaining sterile medical products.

Sweden presses D_2O reactor concept

Stockholm Development of a new reactor concept and postponement of the building of a materials testing reactor are the latest developments announced by AB Atomenergi, the Swedish joint government-private industry company.

The new concept is stated to be a ' pressurized heavy water reactor of the homogeneous type (PHWRH) ' on which work first started in 1959. It is closely related to light water systems and is said to be an extension of the ' cross-flow concept ' in which fuel elements are laid across the flow of heavy water. This is said to allow more efficient flow-through of D_2O and more direct contact between the heavy water and the fuel. The fuel elements would not be set in clusters but would be evenly distributed.

Results so far have been so promising that further detailed investigation is underway. Other companies associated with the concept are Rederi AB Nordstjernan and Atomkraftgruppen who in turn are co-operating with Westinghouse and the Betchel Corporation of the USA.

Meanwhile, DX, a materials testing reactor planned for the Studsvik Research Station, has proved so much more expensive than originally thought, that it has been decided to postpone any decision. The new cost was double the original estimate. Studsvik's facilities include two research reactors, R0 and R2.

• **United Kingdom** Administrative staff cuts involving some 200 people, mainly at head office and in the publicity department, have been made by the GEC as part of an internal re-organisation plan.

• **United Kingdom** The Electricity (Amendment) Act has received Royal Assent. It enables the CEGB nuclear power stations to be used, as required, for the production of radioisotopes.

• **W. Germany** Deutsche Babcock u. Wilcox says its work on the advanced gas-cooled reactor will be completed as scheduled.

Study Group revises Insurance Report

London Another look at the insurance problems arising from atomic energy is taken by a study group of the Insurance Institute of London in a recently issued report.* This brings up to date a previous publication released in December 1956.

Three problems are dealt with: 1, how the risk (nuclear) arises; 2, the nature and probable extent of the damage and liability, and 3, the extent to which existing policies apply and the steps which might be taken to maintain, restrict or provide protection against loss or liabilities which may fall on individuals or corporate bodies. Marine insurance is not covered as no member of the group was engaged in day-to-day study of these problems and because the marine insurance market was itself studying the position.

An interesting item is the group's feeling that there is a need for full guidance in the shape of Ministry of Transport regulations on the carriage of radioisotopes. As time passes, the report points out, more and more firms, who regard a radioisotope as just another tool of the trade, may become lax in enforcing of rules. Already, there have been a few incidents where radioisotopes have fallen from a vehicle and been picked up by the public.

* '*Atomic Energy—Insurance problems arising therefrom*'. *Insurance Institute of London*, 5/-.

• **IAEA** An advisory panel has completed a favourable evaluation of the safety of the Netherlands High Flux Reactor, an enriched fuel, light water moderated 20 MW reactor nearing completion at the Petten Research Centre.

• **United Kingdom** A public inquiry into the CEGB's proposal to build a nuclear power station at Wylfa, Anglesey, is to be held on May 30. It will also deal with proposals for a 400,000 volt double circuit overhead line from Wylfa to a proposed new sub-station.

• **W. Germany** The West German Lower House has approved the 1961 Atomics Ministry budget (see *Worldview*, December, 1960, p 77).

Mining of uranium in Finland started on a small scale in 1959 and shown here is the uranium concentration plant operated by Atomienergia Oy in the north. The company is based on Helsinki and is a consortium organized by five northern pulp and paper companies

UK-Canada row goes to Cabinets

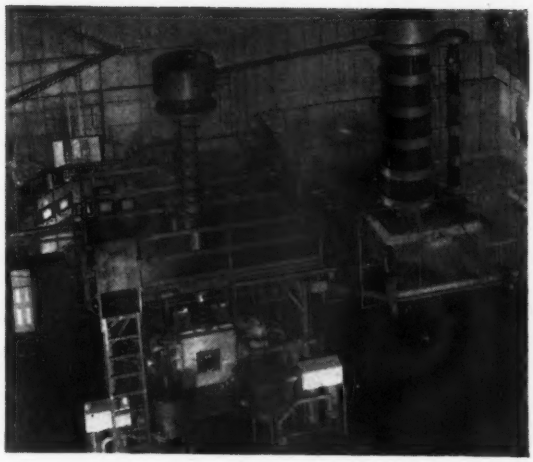
London Confusion over the letter of intent sent by the AEA in 1957 undertaking to buy some 12,000 tons of Canadian uranium is to be discussed at Cabinet level by the UK and Canada. Until this is held, a planned London meeting, between a four-man delegation from Eldorado Mining and Refining Ltd and AEA officials, has been postponed.

The first inkling of the so-called 'secret' contract came when Mr W. M. Gilchrist, president of Eldorado, told the Canadian House of Commons research committee the Eldorado had a 'firm' contract with Britain for 12,000 tons of uranium to be supplied between 1963-66. He said that his company assumed that an exchange of letters of intent was a firm contract.

An official AEA statement avoids a reference to a 'firm contract' but states that in 1958, the Authority indicated they would like to re-negotiate the terms of 'the arrangement'. Since then and most recently in November 1960, the Authority and Eldorado have held discussions regarding the possibility of major adjustment in the programme. Meanwhile, Mr Macmillan, the Prime Minister, is reported to have said in Canada that Britain wished to re-negotiate the proposal as she did not need such large supplies as the 12,000 tons she had arranged to buy.

The main reason behind the controversy over the letter of intent is that since November 1959, the Canadian uranium industry has been in a state of recession. This followed the US announcement that she would not continue contracts for Canadian uranium after 1962 and 1963. Shortly afterwards, a 'stretch-out' agreement was reached on earlier UK contracts for Canadian uranium under which the period for delivery was extended. The further delivery of 12,000 tons would keep many mines in production.

The price agreed upon in the letter of intent is $8 a lb (about £2 17s). Canada has said she would be prepared to re-negotiate the price but not the amount involved. The total cost to Britain at the 1957 agreed price would be about £68 million.



One approach to controlled fusion is the DCX Accelerator System used for experiments at the Oak Ridge National Laboratory, Tennessee. This device is used to inject a beam of high-energy ions into an 'evacuated' machine (lower centre). At upper centre is a cascade accelerator tube connected to a high voltage generator (upper right). If this hot-ion injection system can be successfully developed, it could possibly produce a thermonuclear reaction itself

Europe steps up marine reactor activity

Brussels In contrast to the UK, there has been a spate of activity in Europe on marine reactors. Not only have there been firm research and development contracts placed by Euratom with several French and German companies but the Italian National Committee for Nuclear Energy (CNEN) has signed a two year development contract with Fiat and Ansaldo. in addition, GKSS of Hamburg has signed an information exchange agreement with a Japanese company and the West German Atomics Ministry has signed a development contract with Machinenfabrik Augsburg-Nurnberg (MAN).

The ENEA has also been in the picture with two working groups due to report this September on the possibility of a joint European ship project.

Euratom, in addition to its research and development participation contract with the German firms Interatom and GKSS of Hamburg (see *Worldview*, April, p 71) is negotiating similar contracts with the Italian firms Fiat and Ansaldo for a light water-cooled, enriched uranium reactor; with the French AEC on an advanced gas-cooled reactor and with a Dutch group for development work on a PWR.

The German-Japanese agreement is between GKSS and the Japanese Research Association for Nuclear Ship Propulsion (see *Business*, this issue). Technical information and personnel will be exchanged.

The latest development has been the award of a development contract by the West German Atomics Ministry to MAN. The Ministry has agreed to grant a subsidy of up to 3·2 million D-marks to MAN for a marine pressurized water reactor design study. Cost of the project is estimated at 6·4 million D-marks (£540,000). Aim of the study is to establish whether the MAN reactor will be suitable for marine propulsion and also for use in small nuclear power stations. The latter is in line with the expressed official West German intention of encouraging the development of small power reactors for export.

The CNEN-Fiat/Ansaldo contract follows the submission by the two firms of a nuclear tanker study to Euratom. Under the terms of the contract, the CNEN will put staff and facilities at the disposal of the two firms.

• **Portugal** A study of new sources of electric energy is being undertaken. A report will be issued towards the end of the year detailing requirements and necessary power stations.

• **W. Germany** A working group for reactor safety has been set up in Mannheim. It will vet reactor installations on behalf of the Atomics Ministry.

• **E. Germany** A protocol has been signed with Poland on co-operation in the peaceful uses of atomic energy.

New UK nuclear group

London A new nuclear engineering group has been formed by Imperial Chemical Industries, Rolls-Royce and the Rio Tinto Company. The new company will be called Nuclear Developments Limited and has a nominal capital of £100. No directors have yet been appointed. The company will meet expected future demand for fuel element preparation and manufacture for civil reactors.

Eurochemic lacks funds

Brussels Lack of funds is holding up work on the OEEC's Eurochemic project for the processing of irradiated fuels. A decision on a detailed preliminary project for the fuel reprocessing plant has been postponed until the conclusion of negotiations for more capital. It is hoped that Belgium will take more shares and that Euratom might come into the project.

WORLDVIEW

Italy makes firm plans for OMR

Rome Italian plans for an organic moderated and cooled reactor, rated at 30 MWt, have gone one stage further with the announcement by the Italian National Committee for Nuclear Energy (CNEN) of 'firm' plans for this project. In addition, CNEN also outlined proposals for a thorium-uranium-233 reprocessing and refabrication pilot plant.

The 30 MWt OMR (see *Nuclear Power*, January, 1961, p 63 and March, 1960, p 94) is expected to be built near Bologna in Northern Italy. The fuel is expected to be uranium oxide elements coated with sintered Al powder and experience from the operation of the US OMRE and the Piqua, Ohio, 11·4 MW OMR, is expected to be incorporated in the design. The plant will be built by Sorin (Fiat and Montecatini) with AGIP Nucleare acting as architect-engineers. It will be sponsored and financed by CNEN. The project has been in the discussion stage for some five years.

The reprocessing plant is to be built in Southern Italy and is to be completed by mid-1963. Allis-Chalmers Mfg. Co. have been conducting a 12 month design and evaluation study of the project. Fuel elements from the US Elk River 22 MW BWR will be treated. Aim of the plant is to study the uranium-thorium cycle having in mind an integrated coupled power reactor reprocessing plant.

• **Euratom** A fusion research contract has been signed with the W. German Plasma Physics Institute. It covers three years and one third of the cost will be borne by Euratom.

• **Switzerland** Plans to build a nuclear power station at Lucens are held up, mainly by finance, the president of Nordostschweizerische Kraftwerke AG told the annual general meeting.

• **West Germany** FR-2, the 12 MWt heavy water cooled and moderated research reactor at Karlsruhe, went critical on March 7.

French research spending

Paris France is estimated to have spent some 2850 million new francs (£212 million) on research during 1960. The figure is expected to rise to 3450 million new francs (£256 million) in 1961. The French General Commissariat for Scientific Research says 1960 expenditure was divided into 780 million new francs for basic research and 2069 for applied research. The French Central Institute for Scientific Research spent 248 million francs of the 1960 total and the CEA 328 million francs.

• **United Kingdom** A team from the Atomic Energy Division of the Geological Survey has carried out a programme of drilling operations on the tidal flats at Southwick, Kirkcudbrightshire, Scotland.

• **IAEA** Yugoslavia has asked the IAEA for assistance in obtaining a research and training reactor (a TRIGA Mark II) and the necessary fuel.

Wigner release carried out on Harwell reactor

London A successful Wigner energy release was carried out on the BEPO reactor at Harwell from April 7–8 (see *Cross-section*, April, p 112). It was carried out by externally heating the air stream normally used to cool the reactor. During the release, the heated air was passed through the reactor for about 22 hours at about 9% of the normal operational flow rate.

Throughout the operation, the reactor was run at about 50 kW so that the burst cartridge detection equipment could be used. The nuclear heating so produced was negligible in comparison with the air heating and had no appreciable effect on the progress of the release.

There has been two earlier successful Wigner energy releases carried out on BEPO. The first was in 1954 and the second in 1958. BEPO, a 6 MWt reactor, started up on July 3, 1948, and is in use for research work and for isotope production.

OVERSEAS

Three US reactors go critical

Washington Three US reactors went critical recently—LAMPRE I (Los Alamos Molten Plutonium Reactor Experiment No. 1) on April 3; ML-1 (Mobile Low Power Nuclear Power Plant No. 1) on March 30 and the Snap 2 Development System (s2Ds) Reactor on April 4.

LAMPRE I was built as part of Los Alamos Scientific Laboratory's programme to develop and test fast breeder concepts. Its core is about six inches high and six inches in diameter. Small capsules of tantalum metal are used to contain the fuel. Heat is removed by a circulating stream of molten sodium and an air radiator is used to cool the sodium, so no useful power is produced. Operating temperature is about 950° F.

ML-1, said to be the world's first mobile nuclear power plant, is a direct and closed cycle gas-cooled system. It is water moderated and generates about 3400 kWt. The plant is skid-mounted in six packages totalling less than 38 tons and can be transported by aircraft. It can be placed in full power operation 12 hours after arrival and moved to a new location 24 hours after shutdown. After testing, the reactor will be coupled to a gas turbine and generator capable of producing 300-500 kWe. It was designed and built by Aerojet-General Corporation which is also building the conversion unit.

The third reactor, s2Ds, is the second to be designed and constructed for the AEC by Atomics International as part of the Systems for Nuclear Auxiliary Power reactor-electric power system for space vehicles (SNAP-2). The reactor weighs 200 lbs without shielding and is fuelled with a uranium-zirconium hydride alloy. The core is 13 inches high and nine inches in diameter. It generates 50 kWt and will be mated to its power conversion unit for ground testing of the complete SNAP-2 system later this spring.

• **Australia** The Government has decided to extend the current taxation concessions on the mining and treatment of uranium ore to June 30, 1968.

• **Japan** Major construction work has started on the US GEC's 12·5 MW direct cycle BWR being built for the Japan Atomic Energy Research Institute. Completion is scheduled for early 1963.

• **India** A search for uranium is being carried out in the Saurashtra, Gujarat and Kutch areas.

• **South Africa** A pilot plant for producing 100 tons of uranium metal and salts yearly has been officially opened in Johannesburg.

• **USSR** Co-operation between French and Soviet scientists is to develop fully in the spheres of atomic energy, and other sciences, according to the chairman of the USSR Council of Ministers after the signing of a protocol with France.

• **USSR** The Soviet Union is now giving assistance in the peaceful uses of atomic energy to 11 countries—six European countries, China, Indonesia, Yugoslavia, Egypt and Iraq.

President Kennedy reshapes the AEC Budget

Washington New budget proposals by President John Kennedy have resulted in an increase of some $30 million in the AEC's budget for 1962 fiscal year. However, the revision has meant the cancellation of the aircraft nuclear propulsion programme, a reduction in the procurement of uranium concentrates, production of special nuclear materials and nuclear weapons.

It is offset, in part, by increases for the development of naval reactors, satellite power sources, nuclear rocket propulsion and expanded research into high temperature materials and high performance reactors. Under these increases, the Stanford linear electron accelerator for which funds were denied during the Eisenhower Administration, will be built ; the Hanford New Production Reactor will be converted to electricity production ; and more money is provided for an experimental reactor (beryllium oxide) for possible future use as a merchant ship reactor and for a new Antartica power reactor.

Referring to the nuclear powered aircraft programme, President Kennedy said: ' Nearly 15 years and about $1000 million have been devoted to the attempted development . . . ; but the possibility of achieving a militarily useful aircraft in the foreseeable future is still very remote . . . Transferring the entire subject matter to the AEC budget where it belongs, as a non-defence research item, we propose to terminate development effort . . . '

Indonesia sends nuclear trainees to Russia

Singapore Further steps are being taken to make Indonesia the Far East's third nuclear power after China and Japan. Ten scientists, according to reports here, are to be trained in the Soviet Union to operate the Russian reactor now being built near Jakarta and also a sub-critical assembly on which work has nearly been completed. Six of the scientists are reported to have already left for the USSR with the others following soon. The Soviet research reactor is expected to be a IRT-1000, similar to the one supplied to Bulgaria (see No. 207, *World Reactor Chart*).

Indonesia also has an agreement with the USA under which a Triga training and research reactor is to be supplied and a construction grant given.

Canadian power costs

Ottawa New estimates prepared by Atomic Energy of Canada Ltd. indicate that the costs of producing nuclear power in Canada are rapidly approaching the costs of conventional power.

Mr J. L. Gray, President of AECL, recently predicted that the CANDU power station, scheduled to begin operations in 1964, will generate power at 5·99 mils per kWh at an average level of operation of 80% of capacity. He further stated that if the station became a two-unit operation the costs would be reduced to 5·16 mils per kWh. This compares with the estimated costs of a coal fired power station in 1964 of 5·13 mils per kWh.

While these are predictions only, the first years of CANDU's operating life may provide the pattern for further and more extensive development on a commercial scale of heavy water reactors.

• **Australia** Further rewards totalling £14,000 are being paid by the Government for discoveries of uranium.

India delays tender date

New Delhi The Indian Atomic Energy Commission is reported to have extended the final date for submission of tenders for its proposed 300 MW reactor at Tarapur from the end of May to August 31, 1961. The two reactor station is scheduled for completion by 1965 and specifications call for a natural uranium-type plant but do not rule out an enriched reactor (see *Worldview*, November 1960, p 71 and May, 1960, p 85). The safeguards question remains unresolved.

• **China** A brief message over Moscow Radio stated that the first reactor of the Chinese People's Republic had gone into operation. (But a Russian-designed TVR-S 7 MWt research reactor went critical at Peking late in 1958—see NP Jan 60).

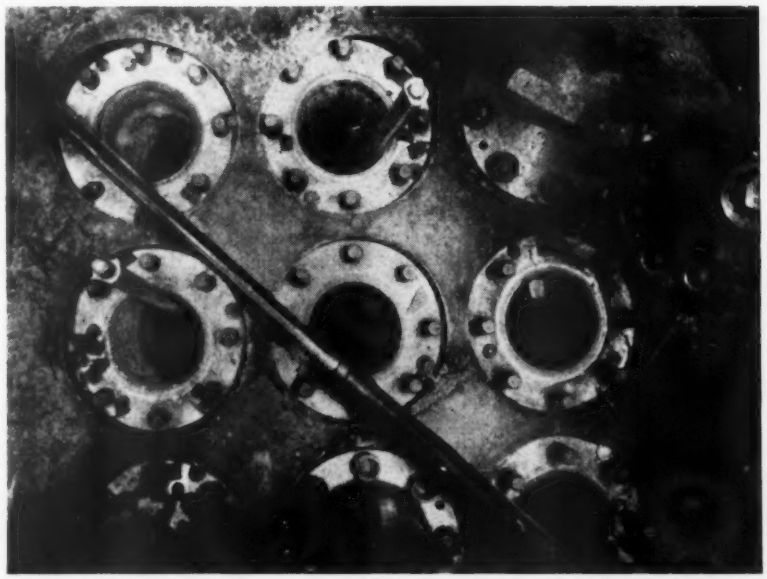
• **India** During India's Third Five Year Plan, £38¼ million will be spent on the nuclear power station to be built at Tarapur.

• **Puerto Rico** A two-storey bio-medical centre, part of the USAEC's Puerto Nuclear Centre, has now been completed.

Consumers BWR research programme develops

New York Contracts for a programme to develop and test cheaper nuclear fuels with increased power density and longer operating life have been signed by the Consumers Power Company, the US General Electric and the AEC. The programme will be carried out at the Consumers Power's 50 MW Big Rock Point direct-cycle BWR. The programme is expected to demonstrate the feasibility of higher heat output in relation to the size of the core, increased dual life and lower fabrication costs.

The Big Rock Point plant, near Charlevoix, Michigan, is scheduled to go critical in September 1962. The initial fuel loading will permit operation at 50 MW but it is expected that during the research and development programme, the generating capacity will be increased to 75 MW. Cost of the plant is estimated at $30 million (£10·6 million).



A view looking straight down on top of the SL-1 reactor involved in the January 3 accident. It was obtained by remote control, using a motor actuated movie camera, suspended from the boom of a crane and shielded from gamma radiation by a lead-lined box. Inferred from the films is that six of the nine nozzles in the reactor vessel top head are open to the atmosphere and that only one (in the upper left hand corner) is completely free of obstruction.

WORLDVIEW

Stainless steel faults cause BWR changes

New York Trouble with the 180MW Dresden boiling water nuclear power plant control rod drives has now apparently been overcome. Operation of the plant up to 100 kWt has been recommended in an AEC's Examiner's intermediate decision. This followed an application by the operators, Commonwealth Edison Co.

The plant was shut down on November 15, 1960 when one of the drives failed. The difficulty was reported due to stress-corrosion cracking of the 17-4 PH stainless steel used in the drive tube. A correction programme is being undertaken in which all material of this specification, including that in the control blades, is to be replaced with similar material treated at 1100°F. (instead of 900°F), providing a material condition which had been shown not susceptible to stress corrosion cracking. Dresden is expected to go critical late in April.

This trouble has had repercussions elsewhere and other reactors using 17-4 stainless steel are to have some parts replaced as a result of the Dresden experience. One of the reactors is the 15MW German Kahl reactor. Here there has been a delay in granting an operating licence and the reason is thought to be to allow time for improvement of the control rod drives. Rod drives of the same stainless steel are also present in the GE of the US VBWR reactor at Vallecitos, in the *NS Savannah* and planned for the 50MW Big Rock Point BWR in Michigan.

An Atomics International technician examines the reflector of the 200 lb S2DS reactor which recently went critical. (See Worldview, this issue, p56)

• **Australia** Mr T. A. Barnes, director of mines for the South Australian Government, is visiting Britain and Europe from May 22—June 11, and will investigate uranium problems for his government.

• **India** The Trombay fuel fabrication plant can produce 30-40 tons of natural uranium fuel elements yearly with future capacity put at 100 tons annually.

• **Japan** The Atomic Energy Research Institute's second research reactor is scheduled to reach a power level of 1MW by the end of April.

• **Japan** A ten-man Nuclear Material Test Reactor Study team is on a two-month tour in the United States. It will investigate the design, construction, cost and operation of reactors and facilities used in materials testing.

• **United States** The AEC has received nine expressions of interest from power organizations to take part in a 50/MW OMR project.

• **USSR** A recent conference on radiation chemistry in Moscow featured the industrial application of radiation chemistry.

Japan cuts atomic energy Budget

Tokyo The Japanese atomic energy budget has followed that of other countries with cuts being made in the overall total compared with the 1960 figure. These have been mainly in long term obligations, leaving activities of the Japan Atomic Energy Research Institute very little affected.

The JAERI, for instance, will still be able to build a swimming pool reactor for marine reactor shielding studies and start work on direct conversion experiments. Contributions from industry to its work—some £250,000—will continue unchanged.

The overall atomic energy budget has fallen by nearly 25% with the cuts falling on the National Institute for Radiological Sciences and on the purchase of special nuclear materials. There is a slight increase in the budget of the Atomic Fuel Corporation which will help in the purchase of a site for a proposed chemical reprocessing plant and finance intensified prospecting for uranium.

US, India sign fast reactor exchange agreement

New York An agreement providing for exchange of personnel and information on fuel and fast reactor technologies has been signed by Atomic Power Development Associates and the Atomic Energy Commission of India.

APDA is the research and development organization for the Power Reactor Development Co's Enrico Fermi 100 MW developmental fast neutron power breeder reactor project. It has signed similar agreements with the UK Atomic Energy Authority and with the Belgian concern, Societe Belge pour l'Industrie Nucleaire.

AEC will convert Hanford NPR to power production

Washington Unclassified studies of generating by-product electricity from the New Production Reactor (NPR), now being built by the AEC at Hanford, Washington, are contained in a recent Joint Congressional Committee on Atomic Energy Print. This says that the electrical plant found to be most economic in the latest studies would have a capacity of 650 MW when operating as a dual purpose reactor for the production of plutonium and by-product power and 760 MW when operated only for power production purposes.

An earlier study on the economic feasibility of converting the NPR for the recovery of electric power was made by the Federal Power Commission and published in February, 1960. Copies of the present JCAE Print can be obtained from the Joint Committee Offices, Room F-88, Washington.

Meanwhile, the Kennedy Administration has allocated $60 million for converting the NPR to the generation of about 650 MW. This expected decision (see *Worldview*, February, 1961, p 57) will mean that the NPR will be the world's largest nuclear power plant.

A feature of this AMF research reactor at the University of Washington, Seattle, is that it is enclosed in glass and located in the heart of the university grounds. This $500,000 'Educator' reactor will be used for teaching purposes

This detailed design for Europe's first joint plant, which will handle a wide diversity of fuel elements, is now being studied by the directors of Eurochemic

Aspects of the Eurochemic reprocessing facility

By Dr T. J. BARENDREGT, Technical Director, Eurochemic

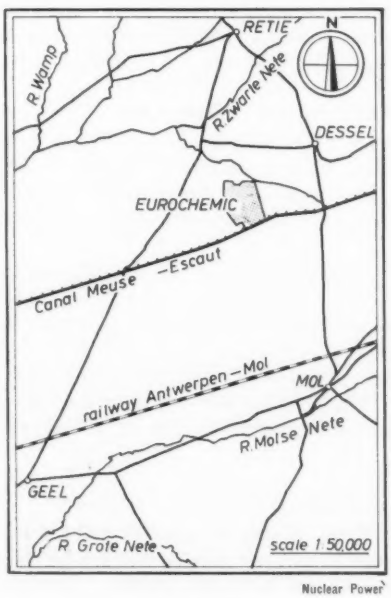
AFTER SEVERAL DESIGNS had been worked out by a study-group of the company, the French firm Saint Gobain Nucleaire was invited to prepare a detailed pre-project for a facility with the following characteristics:

(a) The plant should have a nominal capacity of 350 kg U/day for aluminium and magnesium clad fuel;
(b) For stainless steel or zircaloy clad fuel the nominal capacity may decrease to 200 kg U/day;
(c) The limits of the fuel elements which will be accepted are 5% U/235 enrichment and 10,000 MWd/t irradiation; the cladding may consist of Al, Mg, Magnox, Zr, zircaloy or stainless steel, the core materials of U-metal, UO_2, U-Mo-alloys up to 10% Mo, and later other U-based alloys;
(d) The dimensions of the fuel elements or assemblies are limited to a maximum length of 14 ft and a maximum diameter of 8 in;
(e) The basic flow-sheet, to be adopted should be of the Purex-type (5) with two cycles, utilizing tributyl phosphate as solvent as a 30% solution in a hydrocarbon diluent;
(f) The extraction part of the plant should essentially consist of pulsed columns;
(g) The design should incorporate the particular conditions of the site (Mol, Belgium) where the facility has to be erected;

The organization of the international company for the reprocessing of irradiated nuclear fuel, Eurochemic, has been described by E. Pohland (1). In some recent articles (2) (3) (4) the immediate and long-term interests of Eurochemic have been reported, as well as short descriptions of the actual plans regarding the construction of what has been called 'a small development production facility'.

(h) The design should have a maximum flexibility to maintain the pilot character of the plant;
(i) Having fulfilled the necessary health and safety precautions, the plant should be designed for a minimum cost.

It is obvious that the various requirements are to a certain extent contradictory and it was necessary to come to a compromise solution. The detailed pre-project was



Nuclear Power

(Left) Location of the Eurochemic site (Fig. 1a)

(Below) Map of the northern part of Belgium and surrounding countries showing the position of Mol (Fig. 1b)

Nuclear Power

completed in March 1961 and project work has now started.

SITE CHARACTERISTICS

The Eurochemic site is an almost square piece of land, of some 250 acres, situated on the Meuse-Escaut canal, north of the Belgium national institute for atomic energy research (CEN). It consists of almost pure sand, 80 ft above sea level with some small sand dunes. The ground water table is as an average 3 ft below the surface (Figs. 1a and b).

The area is rather densely populated, although there are no large towns nearby. Agriculture is practised in the area and a milk collection station is located at six miles from the Eurochemic site. However, due to the poor soil, agriculture is not the main employment; some glass factories are located in the neighbourhood. No one lives permanently within a distance of one mile from the projected plant.

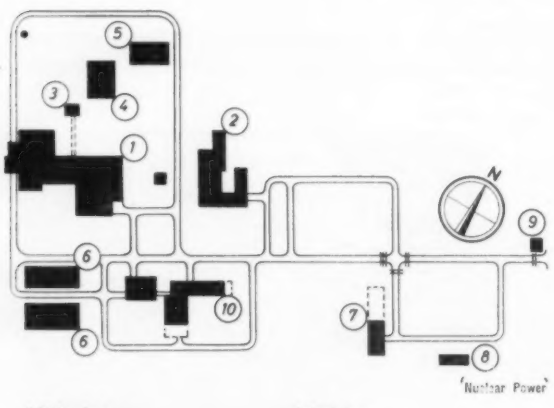
Due to the high ground water table, the plant will be almost entirely constructed above ground to minimize the risk of contamination of the ground water. An advantage is the low speed of the ground water, only a few hundred feet per year from the canal to the north. The possibility of release of gaseous and liquid effluents is therefore very limited. As there is no large river nearby, most liquid effluents will be transported in pipelines to the liquid effluent treatment station of the CEN. This station releases liquids to a small river, some eight miles south of the site.

SITE LAYOUT

The main process building will be situated parallel to, and about 1,000 ft from the Meuse-Escaut canal. North of the plant will be the fission products storage facility, the purified uranium and plutonium products store and the liquid effluent station (Fig. 2).

Power is supplied by two steamlines of 13 atm from a 125 MW conventional power station on the southern side of the canal. This station will also supply the electricity at 26 kV; a transformer station and a steam distribution facility will be located 400 ft south of the main process building.

The plant will contain a large reception and storage hall, an active cell-block, with access, maintenance and control corridors on the southern side. On this side the analytical laboratory for process-analysis is connected to the main building.



1 Main plant
2 Research laboratory
3 High level waste storage
4 U and Pu product storage
5 Effluent treatment station
6 Tank farm
7 Administration
8 Canteen
9 Guard
10 Workshop and utilities

Site lay-out (Fig. 2)

RECEPTION AND STORAGE AREA

Inquiries in the member countries of Eurochemic have resulted in a preliminary acceptance programme for the irradiated fuel elements. To facilitate the design of the reception area 'Eurochemic fuel element receptance criteria' have been worked out (*6*) and are currently under discussion with reactor owners and transport authorities. Until 1967 it is envisaged that irradiated fuel elements will come from some 10–15 different reactors, at present in operation, under construction or in an advanced planning stage. This variety calls for a versatile reception and storage station.

The part of the plant for the reception, storage and transport to the dissolvers of the irradiated fuel elements will be a hall with a length of 220 ft, a width of 55 ft and a height of approximately 90 ft. It can be divided into: (*a*) reception area of the transport containers; (*b*) decontamination and control room; (*c*) three water basins; (*d*) a platform for charging of the dissolvers; (*e*) a water treatment facility.

Reception area for transport containers

The reception area and the possible storage of the transport containers will be situated on the west side of the main plant building; it will have a length of 50 ft to receive the entire transport facility during unloading and reloading of the containers. The floor of this part of the hall will for this reason be strong enough to receive 80-ton containers. The dimensions of the containers which can be received are limited to 8 x 10 x 17 ft. An 80-ton capacity crane is foreseen to remove the transport containers from the truck and to place them either in the storage room or in the decontamination room near the reception area.

Decontamination and control room

This room should serve as a control room to investigate possible contamination, caused by defective fuel elements, to the cooling medium of the transport container and its inside surface, before transportation to the reception basin.

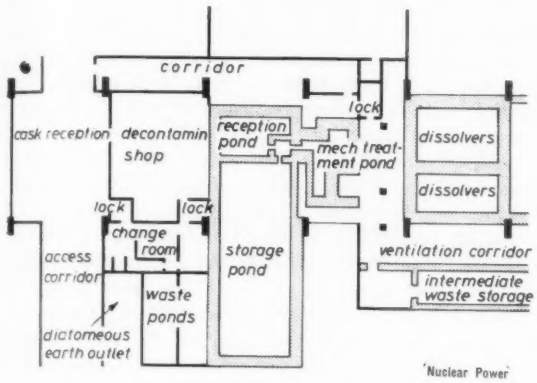
Furthermore, it may serve as a decontamination room for the transport containers before reshipment to the reactor sites. Finally, contaminated plant equipment could be treated.

The dimensions are 40 x 40 x 25 ft, with large openings at the top to permit the entry of the transport containers. The equipment consists of the usual decontamination facilities.

The water basins

The handling of various types of fuel elements in the same storage basins has complicated the layout considerably. To avoid as much as possible frequent handling

of the same elements, the water basins will be divided into three parts: (*a*) the reception basin; (*b*) the storage basin; (*c*) the mechanical handling basin, with the following dimensions: 30 x 17 ft, 30 x 80 ft and 15 x 30 ft respectively. At present two possible layouts are under discussion, either all three basins as one long one with two divisions or the two first ones parallel with the third one as indicated in Fig 3.



Plan view of reception and storage (Fig. 3)

In the first alternative, the fuel elements can be transported to the various basins by one lifting device, circulating on top of the entire facility. However, it will be difficult to keep the air over the surface of the mechanical handling basin free from radioactive contamination and it would be advisable to separate this part from the rest of the hall. Although it is not the intention to cut the fuel elements in the active parts, any mechanical treatment would risk the release of fission gases. An arrangement, as indicated in Fig. 3, would enable a complete separation of the mechanical handling facility from the rest of the hall but the transport of the fuel elements would be more complicated, requiring at least two lifting devices. In the reception basin, the transport container is unloaded and the fuel elements are tested for tightness. They are then placed in storage racks and transported under water to the storage basin. The storage racks will be for use either for natural uranium or for enriched uranium fuel. Criticality risks will be avoided by utilizing safe geometry in the latter case. In addition, the storage of enriched uranium fuel will be impossible in the storage basin area meant for storing natural uranium fuel. An overall safe storage for both natural and enriched fuel would require a very large area and is not considered necessary. The storage basin will be able to contain approximately 80 tons contained uranium. The layout has been chosen according to the charges which may be expected from the various reactors. Locks will be provided between the three basins, to avoid contamination of all basin water, in case of release of fission products in one basin only.

The platform on top of the dissolvers

Charging of the dissolvers will be carried out by the large over-head crane. The fuel elements will be lifted into a lead-shielded transfer coffin on top of the mechanical handling basin and the coffin placed over the dissolver cell. A seal prevents any direct connexion between dissolver and reception and storage area. The transfer coffin is sealed before the dissolver valve is opened. A second valve is provided for safety reasons.

The water treatment facility

A circulation of 30,000 gal/h over filters and ion-exchangers is expected. Furthermore, fresh water can be introduced and contaminated water sent to the liquid effluent station. The circulation is achieved by pumping the water from the bottom of the mechanical handling basin and introducing treated water at the top of the storage basin.

DISSOLUTION AND FEED ADJUSTMENT

It was decided to keep all mechanical treatment of the fuel down to an absolute minimum. Only end-pieces and, eventually, cooling-fins would be removed by sawing or other mechanical operations, but no dividing of core material was foreseen. As a result, the dissolver had to be designed for the reception of rather large units both in length and in diameter.

Criticality considerations limit the diameter of the dissolver vessel. This results in a long dissolver tube, rather than a vessel, to arrive at a nominal capacity of 350 kg U/day, for natural uranium. Another possibility was introducing of fuel elements during the dissolving process. However, to separate the decladding solution and uranium solution, one is bound to introduce the fuel elements batch-wise. Depending on the nature of cladding and core material, a total dissolution cycle (charging of the dissolver, introduction of chemicals, heating, decladding, cooling, emptying, rinsing, introduction of chemicals, heating, dissolution, cooling, emptying, rinsing and a final wash) will take on the average 48 h. A batch of natural uranium will, in this case, be 700 kg contained U.

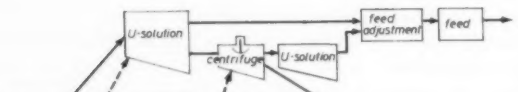
The first dissolver should be able to contain in an ever-safe condition fuel with an enrichment of maximum 1·6% U-235. This limit was chosen largely to meet the reprocessing demands in the first years of operation and to relate the dissolver vessel design as far as possible to a conventional type. The permitted diameter of such a dissolver will be approximately 1 ft. It is obvious that a load of 700 kg contained U in a one foot diameter tube will leave little room for the chemicals required for dissolution. The solution has to be circulated, either by natural circulation, air-lift or other means through a larger ever-safe recirculation vessel, or the solution has to be introduced continuously and the final solution removed during the dissolving process. The present dissolver design has two alternatives: chemicals can be introduced during the dissolving procedure and the solution is removed by means of an overflow into an ever-safe storage vessel of 600 gallons. However, it will be possible to reintroduce the removed solution from the storage-vessel back into the dissolver by means of an air-lift. The storage-vessel has a volume which allows the total required amount of chemicals to be introduced at the start of the dissolution procedure, which would mean a true batch-wise dissolution.

The advantage of batch-wise dissolution is the absence

of a continuous required control of the concentration of the solution leaving the dissolving tube. The disadvantage is the low speed of reaction at the end of the procedure since no fresh chemicals are introduced. The free acid concentration would consequently decrease to a degree that a heel of U would have to be left in the dissolver to meet a reasonable time schedule. This would complicate the introduction of new fuel elements. Another disadvantage is the different volume of chemicals necessary during decladding and dissolution of the core. Dissolution of zircaloy and stainless steel claddings requires, in most cases, appreciably larger volumes of chemicals than the amount of concentrated nitric acid required for the dissolution of uranium oxide.

The off-gas system differs from the conventional in that the gas-liquid mixture is separated at the large surface of the recirculation vessel before the gases enter the condenser and recombination towers for the oxidation of nitrous gases. The passage of the gases through the recirculation vessel prevents entrainment of solid particles into the condenser as the foam produced in the dissolver tube will be largely eliminated due to the large surface of the recirculation vessel. This phenomenon has been studied in laboratory experiments and it is felt that the foam problem will not give rise to any particular difficulties in this arrangement.

A complete separation of decladding solutions and uranium solutions is envisaged immediately after the dissolver recirculation vessel. Losses of fissile material will be limited and the risk of critical conditions due to maloperations is avoided.



Block diagram of the head-end (Fig. 4)

The decladding solution is transferred by means of an air-lift to a catch-tank with ever-safe geometry, from which the solution can be analysed. Where uranium or other fissile material is present, the solution will be centrifuged to remove any solids which may contain uranium. After centrifuging, the decladding solution is once more analysed from an ever-safe tank before it is sent to the liquid effluent station into a non-safe tank.

The uranium solution is also transferred by means of an air-lift from the dissolver recirculation vessel to a second catch-tank with ever-safe geometry for analysis. In the absence of solid particles, the uranium solution is diluted and transferred to non-safe feed adjustment tanks. If solids are present, the solution is centrifuged by a second centrifuge before dilution and transfer to the feed adjustment tanks.

A block-diagram of the head-end is shown in Fig. 4 Room is left for a second dissolver for the treatment of fuels with an initial enrichment of more than 1·6% U-235. This dissolver is at present under study and the intention is to construct a full-scale model in stainless steel to acquire experience with the operation of a semi-continuous dissolver.

EXTRACTION

The extraction part of the plant does not contain special design features. The extraction equipment will be pulsed columns achieved either by mechanical device or by compressed air. The latter method is at present being studied in a full-size experimental column at the Eurochemic laboratories. To avoid entrainment of solids formed at the interface between aqueous and organic phase, the continuous organic phase has been adopted for the two decontamination columns.

Though the equipment design is conventional, there are some important deviations from the original Purex-system (*5*), where two extraction-cycles with intermediate concentration of the U-Pu-solution are used. In the Eurochemic flow-sheet, the co-decontamination of the feed solutions is restricted to the first part of the first cycle without intermediate back-extraction and concentration of the U-Pu-solutions. However, the scrub-section of the first extraction-column is divided into two individual columns, permitting the use of two different scrub acidities and eventually two different temperatures.

To avoid any criticality risk without the obligation to design all equipment geometrically safe, a diluted flow-sheet has been adopted with a feed concentration of uranium as low as 143 g/l. To obtain a high decontamination factor and a maximum yield, the conditions have been chosen as illustrated in Fig. 5. One of the main differences with the original Purex-system is the 4·0 1·5 M HNO_3-scrub resp., whilst in the Purex-system 2·0 M HNO_3 is utilized. A better decontamination factor for both zirconium and ruthenium might be expected.

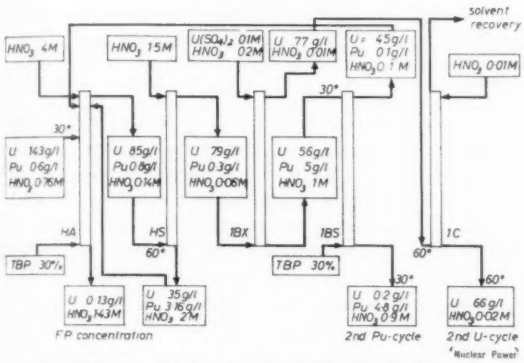
FISSION PRODUCT CONCENTRATION

This part of the plant concentrates as far as possible the highly radioactive solutions which have to be stored so as to minimize the volume. Three additional functions of the acid recovery system have to be met. The distillates should be decontaminated so that they can be used for other, less active, parts of the plant or so that they can be considered as medium active effluents. The recovery of nitric acid should be as complete as possible to diminish the volume of residues, which have to be stored. Losses of uranium and plutonium in the effluents of the final purification cycles have to be minimized.

Considering these requirements, three evaporators have been envisaged. The first evaporator, which concentrates the effluents of the first extraction cycle 10 times as an average, is a batch evaporator with a capacity of 500 gallons. The concentration of the fission product solution is limited, due to the gamma-decay heat, to 9000 c/l in case of efficient cooling possibilities. Heating is achieved by a simple heating jacket around the evaporator, instead of an external or internal coil, in order to minimize the risk of leakage of fission product solution into the heat-

ing system. To avoid nitration of entrained organic material, the temperature of the evaporator will be limited to 135°C by using steam (3 kg/cm²) as heating medium.

As the feed of this evaporator will be 1·5 M nitric acid (see Fig. 5), the distillate will be essentially water. After concentration to approximately 6 M HNO_3, further concentration will be carried out by feeding the effluents of the first cycle together with water to obtain 0·5 M HNO_3 in the distillate. The concentration of the solution to higher acidities than 6 M HNO_3 would complicate the procedure, due to corrosion of the stainless steel. To minimize the corrosion and the concentration of iron in the solution, the evaporation will be carried out in a vacuum of 0·4 kg/cm² obtained by a steam jet.



Flow diagram of the first extraction cycle (Fig. 5)

The second evaporator, identical with the first one in shape and capacity, receives under normal operation the distillate of the previous one, and various streams of medium activity, such as the aqueous effluents from the second uranium cycle, and the nitric acid solution obtained from the recombination of nitrous gases during dissolution of core material. The distillate from this evaporator may either be sent to the liquid effluent treatment station, or when it contains an appreciable amount of nitric acid be utilized as scrub solution in the extraction cycle. The concentrate is normally used in the dissolution step. The two evaporators are interchangeable, to secure in case of failure of the first one, the concentration of high active waste solutions.

A third evaporator is foreseen for the treatment of waste solutions containing fissile material, which may be the case for aqueous raffinates of the solvent recovery system. The unit will work according to the thermosiphon principle and is geometrically safe.

CONCENTRATION OF URANIUM

Two intercycle uranium evaporators are foreseen with identical characteristics. Both are geometrically safe to a concentration of 1000g/1 of U for 5% enrichment and recirculation is achieved by thermosiphon. Feed and product removal are continuous. The evaporators consist essentially of a boiler, a recirculation tube, a phase separation part and a plate column. The lower part of the column will be utilized as a steam-strip for the fuel, which may still contain organic solvent, the upper part to avoid entrainment of liquid into the condenser. The boiler will be a vertical tube type with natural circulation. Like in the other evaporators, the temperature of the heating medium is limited to 135°C, to avoid explosive reactions between nitric acid and organic compounds. The condenser will also be a vertical tube bundle, the vapour condensing at the inside of the tubes. The feed will be maintained constant during the operation by means of a controlled air-lift. The removal of the concentrate follows by overflow, thus keeping the control-devices of the evaporator at a minimum. The condensate is partly re-used as stripping agent in the uranium back-extraction column (IC) (see Fig. 5). The third evaporator of the acid recovery system could be used as a standby in case of failure of the uranium evaporators.

After the second uranium concentration, the final purification and concentration of the uranium solutions is achieved by a silica gel column in a separate cell of the plant. Storage of uranium solution is scheduled in a separate building, north of the plant.

FINAL PURIFICATION OF PLUTONIUM

The quantities of plutonium will be rather small in the first years of operation. Because of the pilot nature of the plant, it was decided to postpone the decision on the choice of purification method for plutonium. At present, extraction of plutonium with trilaurylamine in hydrocarbon solution is being studied in the Eurochemic laboratories. Only one large cell is foreseen but no layout or design of the equipment is at present available.

Rework

Special attention is paid in the layout of the facility to the possibility of reworking various solutions in case of maloperation or malfunction. A large rework area with various equipment is inherent to the character of the plant. As already described several items are interchangeable. In addition a separate rework system is envisaged.

The possibility of transferring solutions from different parts of the system to this rework system brings several complications and disadvantages. The pipe layout will be longer and more complicated, more air lifts or other transfer-means have to be included than in a facility where the same process is utilized. As a result control will be difficult and the risk of maloperation greater. However, the large variety of fuel to be treated and the experimental character have lead to the adoption of an extensive rework system.

Three geometrically safe tanks of resp. 375, 750 and 125 gallons have been scheduled for the reception of solutions from head-end, feed-adjustment and extraction cycles, as an intermediate storage before extraction and as intermediate storage before concentration. Depending upon the nature of the solutions, provision will be made for the separation of aqueous and organic phase in an 80-gal. vessel of particular shape, re-extraction of U and Pu from the organic phase in a mixer-settler unit, filtration of aqueous solutions, concentration of aqueous solutions in a geometrically safe evaporator and finally a kind of evaporator for the hydrolysis of degradation products of the solvent to phosphoric acid, in case fissile material is present in the carbonate wash solution of the solvent recovery.

SOLVENT RECOVERY

Two solvent recovery cycles are envisaged. The design capacity for both cycles is 50 gal/h, corresponding to a production of 400 kg U/day for the first cycle and intermediate storage capacity before and after the solvent recovery system of 24 h.

The solvent will be heated to 60°C before treatment in a 3-stage mixer-settler unit with caustic soda solution. Because of the lower activity level in the second uranium cycle, the corresponding mixer-settler unit in the solvent recovery system of the second cycle will contain only two stages.

After the alkaline wash of the solvent, a filtration will be used to remove any solid particles still present and to separate possible aqueous entrainment from the organic phase. The solvent is then cooled and after intermediate storage either used for the extraction or sent to the effluent station. The alkaline wash solution is normally sent to the waste system unless presence of fissile material necessitates a new treatment in the rework system.

As the activities in this part of the system are comparatively low, submerged pumps will be used to transfer the solutions rather than air-lifts or steam jets. However, steam jets are expected to be used to transfer the solvent solutions to the rework system and to empty the storage tanks entirely.

SAMPLING SYSTEMS

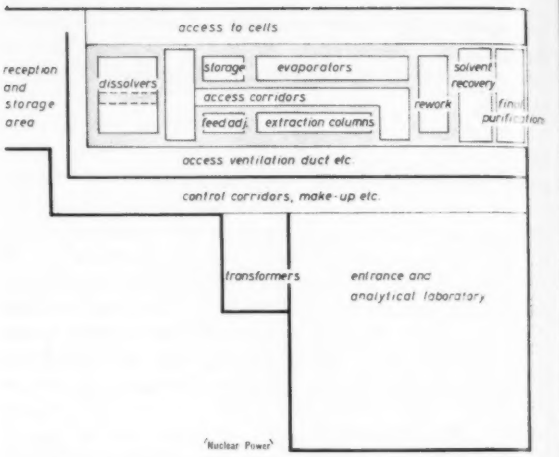
Although some in-line instrumentation for the determination of gamma-activities in particular streams is expected, the pilot character of the plant prevents a complete automatized process and many sampling points are foreseen. After careful examination of the various existing sampling devices in reprocessing plants, the so-called Thorex-system (7) has been chosen for the Eurochemic facility. The sample transport to the analytical laboratory will be achieved by a pneumatic system to avoid the rather troublesome transport of shielded containers in the sample gallery.

Plant layout

The active cell-block consists essentially of four parts, the head-end, the extraction and concentration, the rework and solvent recovery and the final purification area (Fig. 6). This cell-block has a length of 240 ft, a width of 55 ft and a height of 60 ft.

The head-end part will have two dissolver cells, an off-gas treatment located above the dissolver cells, a storage and a make-up cell. The length in the east-west direction will be 45 ft. An access zone to the dissolver cells will be provided in the north-south direction, this zone will be connected to an access zone between extraction columns on the south side and evaporators on the north side of the plant. The rework and solvent recovery cells have only access from the south side of the plant. Apart from the small silica gel column cell, no specification is made at present of the final purification area.

All control, maintenance and access corridors are planned for the south side of the plant, the northern side being reserved for equipment removal from the cells. As the extraction and concentration part consists essentially of two rows of cells, the removal of the columns had to be foreseen from the top of the cells. This compromise



Simplified layout of the cell-block and control area (Fig. 6)

solution has been chosen to permit easy access to all parts without more intervention than strictly necessary while still keeping the cell-block compact for cost reasons.

The cell-block has been divided in a rather large number of cells. It is felt that the experimental character of the plant will necessitate frequent intervention, which may result in long decontamination periods. On the other hand, a certain production capacity should be secured and it seems justified to separate suspect units as far as possible, permitting intervention without too long decontamination periods.

SUMMARY

The design of a small development-production facility for the reprocessing of a variety of fuel elements with initial natural uranium or enriched to a maximum of 5% U-235 at a reasonable cost has led to the adoption of several compromise solutions in the choice of the process and the building layout

It is realized that the facility does not have the features of an adequate plant for the continuous processing of large amounts of the same type of fuel. Furthermore, the expected frequent interventions to the cell equipment together with the tendency to restrict the total cell volume have led to a highly subdivided cell-structure to avoid longer decontamination periods.

Considering the particular limitations, due to the location of the facility and the available funds, the realization may contribute to a better understanding of the economic problems involved in the reprocessing of irradiated material from a large variety of reactors and serve as a development unit to gain experience for the participating countries.

References

1. Pohland, E., *Nuclear Engineering*, July 1960.
2. Rometsch, R., *Nuclear Engineering*, July 1960.
3. Rometsch, R., *Mitteilungsblatt des Delegierten für Fragen der Atomenergie*, Bern 1960.
4. Pohland, E., and Barendregt, T. J., *Die Atomwirtschaft*, March 1961.
5. Irish, E. R., and Reas, W. H., TID-7534, Book 1, pages 83-106, Brussels, May 1957.
6. Marcus, F., Eurochemic Technical Report No. 94, November 1960.
7. Bruce, F. R., TID-7534, Book 1, pages 180-222, Brussels, May 1957.

Some interesting results of experience with the reactors at Dounreay were given

Symposium on reactor instrumentation and control

by DENIS TAYLOR, M.Sc., Ph.D., M.I.E.E.,
Director Plessey Nucleonics Ltd. and Hagen Controls Ltd.

THE FIRST PAPER, 'An Introduction to the Control of Nuclear Reactors', by R. C. Wheeler (Dounreay), compared and contrasted the neutron life cycles in the case of (a) the fast reactor cycle, (b) the thermal reactor cycle and developed the equations for the effective multiplications constants.

The author then proceeded to a discussion of the condition for sub-criticality ($k_e<1$), criticality ($k_e=1$) and supercriticality ($k_e>1$), and discussed how the prompt neutron life time (varied from 10^{-3} sec in the case of the thermal, natural uranium, graphite moderated reactors (e.g. CALDER HALL) to 5×10^{-5} sec in the case of the thermal, U-235, H_2O moderated reactors (e.g. LIDO) to 10^{-7} sec in the case of the fast U-235 reactors (e.g. DFR). This led to a discussion of delayed neutrons, with the main group with a half life of 54·5 sec and the fact that the delayed neutrons act as 'pace-makers' for any changes to the system, and the important conclusion that for safe operation it is important not to allow a reactor to enter the prompt critical region (i.e. the region where the chain reaction becomes self-sustaining without the delayed neutrons). The author then went on to discuss how the delayed neutron fraction (β) varies with the type of reactor (see Table I).

It was noted that β, and therefore the margin between prompt and delayed critical is much less for a plutonium-fuelled reactor. It was also noted that the effective delayed neutron fraction for uranium fuelled reactors is nearly always in the range 0·65-0·80% regardless of the proportions of U-238 and U-235 present.

Wheeler then went on to a discussion of the principle of control. The most common method is by the use of an absorbing material; another means is to vary the amount of moderator. Control by varying the leakage is also possible, although movement of massive reflectors is not normally very practicable with large power reactors. It was noted, however, that this method is employed in the case of Zephyr.

TABLE I

REACTOR	TYPE	TOTAL EFFECTIVE β AS %
CALDER HALL	Thermal, Nat. U	0·75
DMTR	Thermal, Enriched U-235	0·67
ZEPHYR	Fast, Pu-239	0·30
DFR	Fast Enriched U-235	0·75

Engineers and scientists working at remote sites often have considerable difficulty in finding the time to attend professional meetings in London. It was therefore an extremely satisfactory move for the Scottish Centre of the Institution of Electrical Engineers to plan a two-day Symposium at Glasgow on the Instrumentation and Control of Nuclear Reactors. The meeting took place at Bearsden, on the outskirts of Glasgow, at the Residential Centre for Management Studies made available by the Royal Technical College for the occasion, and by all standards must be rated a very considerable success. About 120 attended with particularly strong contingents from Dounreay Chapelcross and Hunterston.

The requirements for a control system were then discussed under the following headings:

(1) It should provide enough change in k_e so that on the one hand the reactor may be made critical, and on the other the reactor may be made sufficiently sub-critical for loading and un-loading operations to take place safely. As a working rule only it is often arranged that a reactor should have a negative reactivity $\left(\rho=\frac{k_e-1}{k_e}\right)$ at shut down at least three times larger than the reactivity change associated with any one loading operation, It is also a good general rule that the control system should not have sufficient reactivity available to bring the reactor up to the melt-out or damage power if it were all inserted.

(2) It should provide enough reactivity to over-ride the effect of temperatures as the reactor is brought to power.

(3) It should provide enough reactivity to overcome the effect of fission product poisoning.

(4) It must provide enough reactivity to overcome the effects of depletion or burn up.

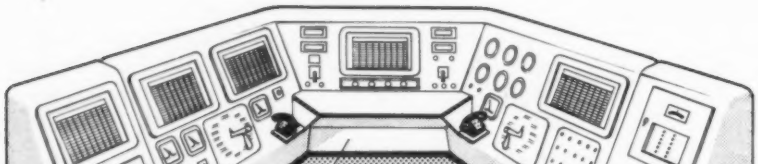
(5) The control system must respond sufficiently quickly to allow signals from automatic shut-down circuits to protect the reactor against accidents.

(6) It must be reliable.

Experience with DFR

The second paper was by J. Allen (Dounreay) on 'Operational Experience on the Dounreay Fast Reactor'. After describing briefly the main features of the DFR, he went on to discuss the initial experience with the liquid metal circuits. He explained that the main objective was to reduce the oxide content of the liquid metal since this oxide was known to have a deleterious effect particularly on the fuel element can materials. Oxide removal is mainly effected by 'cold trapping', this being a technique in which a fraction of the total coolant flow is diverted through a by-pass circuit and cooled. This cooling results in precipitation of oxide out of solution, the oxide then being 'trapped' by deposition on raschig rings in a 'cold trap'. Fig. 1 shows the design of the cold trap.

It was noted that it is necessary to clean the liquid (i.e. clear of oxide) to permit proper operation of control rod members and the author was able to show examples of the sort of surface contamination which was sufficient



'Nuclear Power'

Portable console F low power flux and intermediate power flux

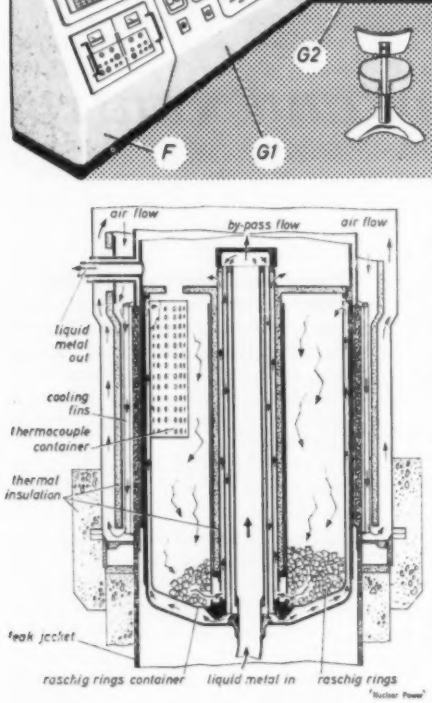
Portable console H master control station, boiler water return, temperature

Desk section G1 control rod selection, reactor power measurements

Desk section G2 total coolant flow indication, power drift and power level, coolant controls

Desk section G3 control rod positioner, master flow control selector, coolant temperature recorder

(Above) Control room of the fast reactor at Dounreay (Fig. 2)



'Nuclear Power'

(Left) Design of the cold trap for the Dounreay Fast Reactor (Fig. 1)

to cause control rod jamming. Apparently as the moving elements pass through the liquid metal surface, oxide may be picked up in the bearings. For all these reasons methods of checking the purity of the liquid metal are important, as well as methods of removing the contamination. The author voiced the opinion that the cold trap method of removal was satisfactory but an improved method of detecting the presence of the oxide (on a continuous basis) would be of value.

The author then described the zero energy physics experiments which had been carried out on DFR. The programme included:

(1) control rod calibration, relative and absolute,
(2) measurement of reaction rates, fission capture, etc., in different sections of the reactor,
(3) activation experiments,
(4) kinetics.

At one stage in the zero energy physics programme the electro-magnetic pumps were brought up to full flow. It was noticed that as the pump flow reached about 70% of its maximum value some fluctuation of the reactor power level occurred. These fluctuations appeared to be a function of liquid metal flow and it was suspected that they were due to the entrainment of the nitrogen blanket gas into the liquid metal coolant, An intensive programme was undertaken to determine the exact source of the gas entrainment. The importance of this lay in the possibility of local over-heating of the reactor core under conditions of full temperature operation, should liquid metal coolant be temporarily replaced by gas. So far results are inconclusive and experiments are being continued.

Discussing the instrumentation of the DFR, the author explained that much of this was conventional, but in the case of the liquid metal cooling circuits, the normal measurements of flow temperature, level and pressure are complicated by:

(1) the presence of the chemically active sodium-potassium coolant or its vapour,
(2) the importance of maintaining the integrity of the liquid metal and associated nitrogen gas blanket circuits.

The first of these led to the extensive use of stainless steel for all components coming into contact with the coolant or its vapour.

In order to guarantee as far as possible the integrity of the liquid metal circuits they were constructed without any flanges or valves, and in the case of the primary circuit almost all the liquid metal pipe work was leak jacketed. This led to the choice of electro-magnetic flow meters for all flow measurements in preference to the usual venturi type. Pressure measurements are made with sealed diaphragm instruments so that failure of at least two seals would be necessary before any loss of blanket gas occurred. Liquid level measurements embody the use of a buoyancy principle in which there are no moving parts in contact with the liquid metal.

One particularly important measurement, that of control rod position, had to be done indirectly. The movement of a soft iron slug (fixed to an extension of the control rod) inside the blanket system is followed by a search coil outside the blanket system again to minimize the possibility of gas leakage.

The author was able to give a good record for the instrumentation for the 18 months the reactor has been operating.

Whole body monitoring

The third paper was on 'Human Body Radiation Monitors' by D. H. Pringle, (Research Enterprises Ltd) and he described, in particular, the four-crystal system which his company have supplied to various AEA Establishments. This consists of two sodium iodide crystals mounted above and two below the patient, mounted in a line with the axis of the patient's body. The crystals are 5 in in diameter and 4 in deep and are viewed by 5 in diameter photomultiplier tubes. The type of room employed has 6 in thick walls lined with $\frac{1}{8}$ in lead.

Instrumentation of DFR

The paper on this subject was presented by R. Smart (Risley). He explained that the reactor power is varied by twelve mobile fuel element rods, which are inserted into the core from below, and three boron rods which are dropped into the inner ring of breeder elements at shut-down. The fuel element rods are identical but have different functions which affect their instrumentation. Two are safety rods normally held in the core and only dropped in emergency ; four are shut-off rods and are fully raised into the core in normal operation and lowered or dropped out at shut-down ; the remaining six are adjusted in normal operation to maintain the desired power level and at shut-down are lowered or dropped out of the core.

Control of reactor power level during start-up and at power is based on a number of neutron flux measurements presented on the control desk. Total primary and secondary liquid metal

coolant flow rates are also controlled from the desk to suit the operating power levels and steam conditions to achieve the required operating temperatures.

The instruments giving the state of the individual coolant circuits are installed on the main graphic panel. These are referred to periodically to check for deviations from normal operating conditions. It was impossible to indicate simultaneously the measurements from all coolant circuits and the mimic diagram was therefore designed to show one complete heat transfer system comprising two primary and one secondary liquid metal circuits and one steam raising unit. It was thus possible by means of 12-point instrumentation to indicate simultaneously:

(1) Coolant flow rates in primary and secondary circuits with total flow recording for core and breeder coolant systems.
(2) Inlet and outlet temperatures to the reactor.
(3) Liquid metal level in expansion tanks.
(4) Blanket gas pressure.
(5) Liquid metal flows and temperature in the thermal siphon system.
(6) Coolant outlet temperatures at selected points below the core and breeder elements, arranged to give the radial temperature distribution within the reactor vessel.

The arrangement of the control desk is shown in Fig. 2.

The author also discussed the measurement of neutron flux, the measurement of flow and level and the measurement of oxide in the liquid, but this was along the lines of his paper presented to the Instruments and Measurement Conference, Stockholm 1960 (see *Nuclear Power*, p. 106, November 1960).

Reactor kinetics

The fifth paper was by D. C. G. Smith (Dounreay) on 'Reactor Kinetics'. He explained the behaviour of a power reactor following a disturbance in reactivity or coolant flow conditions. Firstly, the power would vary in a way determined by the nuclear constants of the fuel and structure. Secondly, the thermal and mechanical properties of the reactor constituents would lead to changes in physical condition such as density, expansion, etc. Thirdly, in the case of thermal reactors, changes in power would modify the fission product poisoning content of the reactor core.

The maintenance of a steady chain reaction depends on the balance between neutron production, loss by absorption and loss by leakage. In the case of reactors having small cores, there are four principal mechanisms producing reactivity changes as temperature is changed, viz.

(i) coolant expansion
(ii) longitudinal expansion of the fuel
(iii) structural expansion
(iv) fuel movement due to temperature gradient.

These four are the main contributors to the fast reactor case. They are, however, primarily attributable to the small core size with its comparatively large neutron leakage and they would be less important in thermal reactors. Three other mechanisms are important in thermal reactors,

(i) Doppler broadening of resonance absorption.
(ii) Effect of moderator temperature on neutron spectrum.
(iii) Effect of fission product poisoning.

Experience with DMTR

W. H. Lunning (Dounreay) spoke about operational experience and A. L. Whitwell (James Scott Ltd) spoke briefly about instrumentation changes proposed. DMTR is a research reactor and has associated with it upwards of 24 Test Rigs for experimental purposes. These test rigs are changing as the experimental programme progresses. In general the rig instrumentation follows the same pattern as that of the reactor. The safety of both depend in large measure upon the quality of the rig instrumentation and the correct decisions on which rig circuits can shut down the reactor automatically in the event of abnormal conditions. This can only be assessed from the detail of the rig and a study of the consequences of malfunctioning.

Magnetic amplifiers

J. A. Purdie (Bruce Peebles Ltd) presented a paper on 'Application of Magnetic Amplifiers to Reactor Control'. He mentioned that reactor rod control motors designed to work at low speeds require low frequency alternating current supplies and under certain conditions the output of these supplies must become direct current.

Purdie discussed a low-frequency supply system which embodies magnetic amplifiers for the generation of power.

The signal to the magnetic amplifiers is derived from a small synchronous link transmitter. Since magnetic amplifiers are simple static devices they offer considerable advantages over the more conventional method of supply which uses a d.c. generator with rotating brush gear.

Improved nuclear instruments

D. Taylor (Plessey Nucleonics Ltd) spoke about improved nuclear measuring instruments. He mentioned the improvements which had been made in ionization chambers and fission chambers to permit operation at higher temperatures, the use of fissile-coated electrodes instead of boron-coated electrodes to avoid depletion problems and give increased sensitivity, the use of boron-coated electrodes in proportional counters instead of using BF-3 filling gas to provide counters capable of operation shortly after prolonged operation at high neutron flux, and the use of a.c. ion chambers with applications to shut-down circuits.

Dr Taylor also spoke at length on solid-state devices as particle detectors and gave some examples of their use in typical instruments. He also had a word or two to say about the future of these devices in multi-channel analysers. He dealt at length with various new techniques including pulse shape discrimination, improvements in controllers, and simplification in indication, as well as the possible application of microminiaturisation and solid circuits.

Human factors

The last paper dealt with ergonomics and was presented by H. D. Howse (Associated Industrial Consultants Ltd). This paper created a great deal of interest and it was followed by much discussion. The author was concerned with a long term study of control room design and the aims which he set himself were on the safety side, to protect the general public and safeguard the operating staff. On the efficiency side, his aims were to operate at the minimum value cost figures by minimizing unnecessary trips, by maximizing electrical power output and by maximizing the life of the equipment.

As a result of the study, it was suggested that man's primary function in this system would seem to be

(a) *Decision-making*, especially in those cases where rule of thumb cannot be applied.
(b) *Early entry into the system* when a deviation condition begins so as to arrest a deteriorating situation.
(c) *Managing the system* so as to optimize the system's aims of safety and efficiency.

On the other hand, the author suggested that man should not be used as

(i) a primary safety device.
(ii) a continuous controller, although he must have facilities to allow him to enter control loops in an emergency
(iii) a monitor: as far as possible monitoring, it is suggested, should be automatic.

The author then went on to discuss the manning and put forward the proposition that 'one mind in control' was correct, from which it followed that one man was needed to see everything, and that all controls should be made as accessible as possible.

This new apparatus has already provided some information about the corrosion of zircaloy-2 in water

Dynamic corrosion testing with water and steam

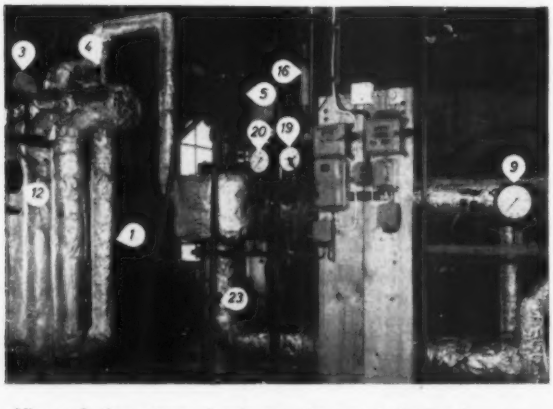
By Dr F. MÜLLER, Sulzer Bros, Winterthur, Switzerland

Little information is available on the corrosion resistance in water or steam atmospheres of new special materials such as zirconium or zircaloy-2 (particularly with respect to the embrittlement of zirconium after absorption of hydrogen). A steam and a water circuit has been designed and constructed by Sulzer Bros. to study susceptibility to corrosion of all reactor materials.

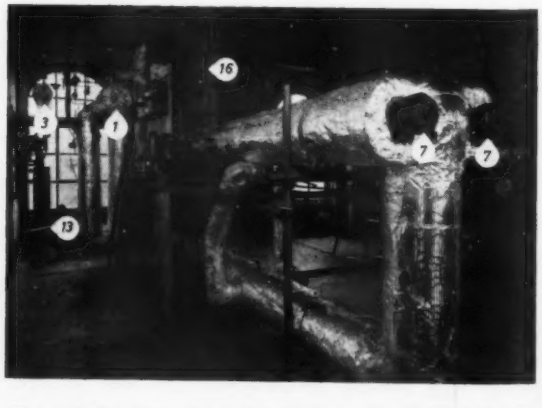
THE STEAM CIRCUIT of a recently developed experimental apparatus consists in essentials of a steam generator with an equalizing tank, the circuit proper and a glandless, fully enclosed circulating pump inserted in it (Figs. 1 and 2). The whole steam circuit, including the pump, is under an operating pressure of up to 100 kg/cm² (1422.3 lb/in²). The bearings of the pump shaft and the electric pump drive run in an inert-gas atmosphere which is in equilibrium with the steam atmosphere. The latter being separated from the gas by a special sealing system. All parts coming into contact with the circuit steam, with the exception of the steam generator, are of stainless steel. Great care was taken to degrease all tubes and to ensure the absolute cleanliness of all parts at the time of assembly. The fittings are all packed with sealing materials free from oil and grease. In this circuit specimens can be tested up to 100 kg/cm² (1422.3 lb/in²) and 500°C.

Steam generator

The steam generator (Fig. 3) consists of a small boiler drum with risers and downcomers, the risers being heated electrically in several steps by coils fitted on the outside. The boiler drum is connected on the water side to an equalizing tank, which on the gas side is filled with inert gas. The saturated steam entering the drum flows through a water separator into the pump casing and thus into the circuit proper. Inside the circuit the pump takes the steam from the vertical run of the piping system and forces it into the two horizontal pipes. Each of these pipes is furnished with an autoclave in which the specimens to be tested can be inserted in special holders (Fig. 4). The velocity of the steam can be varied within certain limits by fitting baffle plates. After leaving the autoclaves, the circulating saturated steam is heated by electric coils to the required working temperature (Fig. 3). The flow rate is measured by orifice plates and indicated by pressure-difference measuring cells (Barton cells). The upper space of the circulating pump and the free space in equalizing tank, the sealing-water vessel and the overflow vessel are filled with inert gas and communicate with one another. The gas flows through a silica gel filter before entering the pump body in order to keep any moisture away from the electrical part of the pump. The steam atmosphere is separated from the inert gas in the equalizing vessel by the water level and in the circulating pump by a water seal enclosed between two Simmer rings

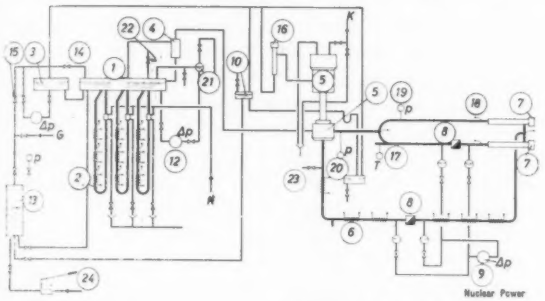


View of the steam circuit on the test-bed; for key see Fig. 3 (Fig. 1)



View of the steam circuit for pressures up to 100 kg/cm² and temperatures up to 500°C; for key see Fig. 3 (Fig. 2)

(10 in Fig. 5). The sealing-water vessel (10 in Fig. 3) ensures that the seal is always filled with water, which is required both for cooling and lubricating the rings and as a supplementary sealing medium. Any upward leakages to the ball bearing are intercepted in the overflow vessel. The water levels in the boiler drum and the equalizing tank are measured and indicated with Barton cells. Make-up water for the steam generator and the sealing vessel is supplied from tank, which is filled with de-aerated and demineralized water. The water is displaced into the vessels as required by inert gas. When the installation is started up, the circuit is filled with inert gas and the steam generator, equalizing tank and sealing-water vessel with de-aerated and demineralized water. Pressure equilibrium between gas and water is established with valve 14, which is closed after filling. When the steam generator heating is switched on, the rising steam pressure forces water into the equalizing tank, so that the equilibrium between gas and water is upset. Valve 15 must then be used to supply inert gas to the equalizing tank and thus to the upper pump space until equilibrium is

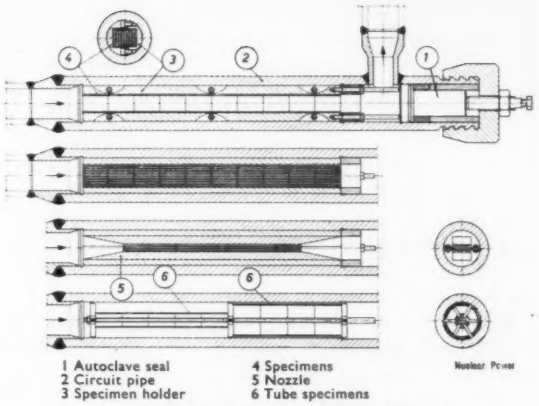


1 Steam generator
2 Electric heating coils
3 Equalizing tank
4 Water separator
5 Circulating pump
6 Electric heating coils
7 Autoclaves
8 Orifice plates
9 Δp indicator, Barton cell
10 Sealing-water vessel
11 Overflow vessel
12 Δp indicator, Barton cell with minimum contact
13 Feedwater and gas tank
14 Pressure equalizing valve
15 Gas valve
16 Silica gel filter
17 Thermostat
18 Thermo-couple
19 Manostat
20 Manometer
21 Steam trap
22 Safety valve
23 Steam sampling cock
24 Hand-operated pump
G Inert gas
K Cooling water

Diagram of steam circuit for corrosion testing (Fig. 3)

again established between the gas and steam phases. This is indicated by the two water-level instruments for the steam-generator drum and the equalizing tank. This process is repeated until the working pressure is reached. In steady-state operation the rings of the water seal only have to take the pressure difference of a few millimetres water gauge due to pressure fluctuations in the steam generator. As the steam pressure rises, the steam-and-gas mixture in the circuit is gradually blown off through air-vent valves until a pure steam atmosphere with an extremely low inert gas content is obtained. Steam samples can be taken by way of a cooler with valve 23. The working pressure is controlled by a manostat which switches the heating coils of the steam generator on and off; it can be kept constant to within ±0.5 kg/cm² (7.1 lb/in²). The steam temperature in the circuit is also kept constant within narrow limits by a thermostat.

The various heating systems, the manostat, the circulating pump and the water-level indicators are electrically interlocked to ensure the safety of the whole installa-

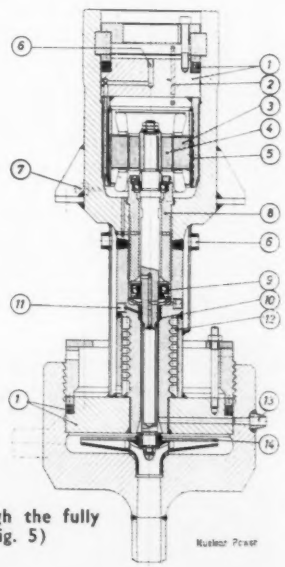


1 Autoclave seal
2 Circuit pipe
3 Specimen holder
4 Specimens
5 Nozzle
6 Tube specimens

Sections through the autoclave (Fig. 4)

tion. Monitor thermocouples shut the system down if the admissible temperatures of the heated pipes is exceeded.

To permit the circulating pump to operate at working pressures up to 100 kg/cm² (1422.3 lb/in²) and steam temperatures up to 500°C without steam losses in the gland (the whole circuit is gastight) and thus under constant operating conditions, a fully enclosed and glandless pump was developed. The whole pump body (Fig. 5) is under working pressure and is closed at top and bottom by an autoclave seal, the upper part as far as the two rings 10 being filled with inert gas and the lower part with steam and a condensate film. While the upper part is connected through branch 7 and the silica gel filter to the equalizing tank, the lower part is short-circuited through branch 13 and the water separator to the steam generator.



1 Upper and lower autoclave seal
2 Power lead-in
3 Stator
4 Rotor
5 Cooling jacket for stator
6 Cooling water
7 Inert-gas inlet
8 Bearing sleeve
9 Lower ball bearing
10 Water seal
11 Sealing water
12 Cooling jacket
13 Saturated-steam inlet
14 Impeller

Longitudinal section through the fully enclosed pump (Fig. 5)

Power is led in at 2. Stator winding 3 is surrounded by a water-cooled jacket for the cooling of the pump motor. The lower part of the pump also has a cooling jacket to protect the sealing rings and the lower ball bearing.

Water circuit

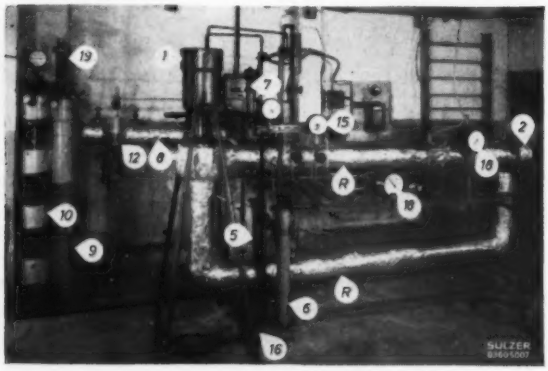
The water circuit is constructed on similar principles to the steam circuit and operates at up to 250 kg/cm²

and a water temperature of 350°C (Figs. 6 and 7). The whole system is under a gas pressure which can be set at anything up to 250 kg/cm² (3555.8 lb/in²). The water is drawn in by the circulating pump from the vertical pipe and is forced into the two horizontal pipes. Each of the two pipes on the discharge side is provided with an autoclave, as in the steam circuit. The material specimens can be inserted in these autoclaves in special holders. The water flow in the pipe system is again measured by means of orifice plates and indicated with Barton cells. The water is heated by electric coils which are fitted on the outside of the suction piping.

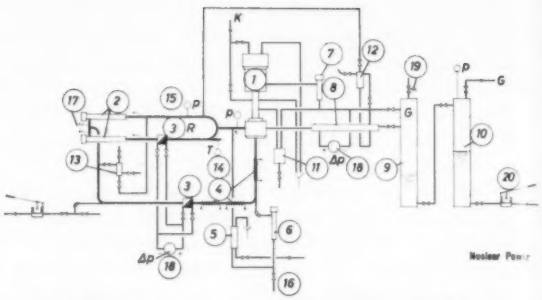
On the water side the pump casing is connected to expansion vessel and overflow vessel, while on the gas side the upper part of the pump body and expansion vessel are short-circuited with the overflow and gas vessel. The whole system is consequently under the same pressure. A silica gel filter inserted in the gas pipe ahead of the pump ensures that dry gas only can enter the latter.

All parts of the circuit coming in contact with the water are of stainless steel, and as with the steam circuit careful attention was paid to cleanliness during erection and to the use of packing materials free of oil and grease for the fittings.

At start up, the whole system is filled with an inert gas up to a few millimetres water gauge above atmospheric pressure. Thereupon, thermally de-aerated and demineralized water is pumped into the pipe system from below till the whole system, including the expansion vessel 8, is full and the water runs over into overflow vessel 9. The upper part of the pump body remains completely dry. The height of the water level in the expansion vessel is measured and indicated by a pressure-difference transmitter. Air-vent valves ensure that all the gas displaced by the water can escape. The pressure is raised to the operating level and the circulating pump and electric heating are then switched on. The excess volume of water resulting from heating is led off into expansion vessel and thence into overflow vessel, so that a constant level establishes itself in steady operation. Small differences of water temperature with consequent level fluctuations in the circuit are equalized by the water present in the expansion vessel. The working temperature, which can be adjusted within wide limits, is automatically regulated to an accuracy of ±2°C by a thermostat which switches



View of the water circuit on the test-bed. Working pressure up to 250kg/cm², temperature up to 350°C; for key see Fig. 7 (Fig. 6)



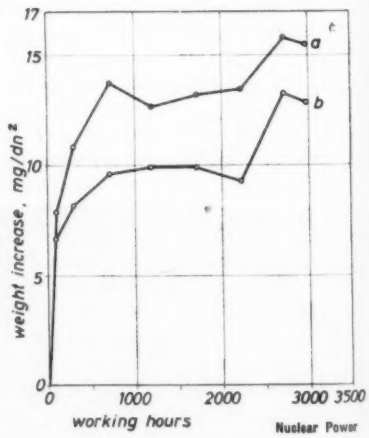
1 Circulating pump
2 Autoclaves
3 Orifice plates
4 Electric heating coils
5 Cooler
6 Ion exchanger
7 Silica gel filter
8 Expansion vessel
9 Overflow vessel
10 Gas reservoir
11 Spray-water overflow vessel
12 Gas sampling cock
13 Chemical admixture vessel
14 Thermostat
15 Pressure monitoring manostat
16 Water sampling cock
17 Thermo-couples
18 Δp indicators, Barton cells
19 Safety valve
20 Hand-operated pump

G Inert gas
K Cooling water
R Pipe system

Diagram of water circuit for corrosion testing (Fig. 7)

heating coils on and off, and is further monitored by thermo-couples. The working pressure is kept constant by the inert gas. Part of the water is passed through an ion exchanger charged with lithium in order to eliminate any Fe ions from the circuit and to keep the pH-value to the desired level. Sampling cock 16, preceded by cooler 5, permits investigation of the water quality. The properties of the water can be altered at will during operation by adding chemicals in vessel 13. A special vessel 12 enables gas samples to be taken, for instance for the purpose of determining the H_2 concentration in the inert gas.

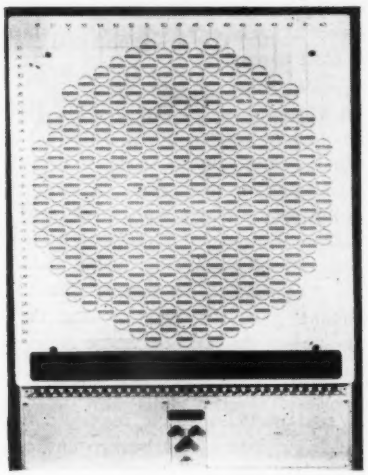
The water is kept in circulation by a pump of the same basic design as that used in the steam circuit. The only difference is that the gas phase is no longer separated from the water phase, so that the circuit water comes into contact with the inert gas in the annular gap between the pump shaft and the pump body.



Corrosion tests on zircaloy-2 specimens subjected to different heat treatments (curves a and b) in the high-pressure hot-water circuit. Working pressure 140 kg/cm², temperature 300°C (Fig. 8)

The water circuit has already given complete satisfaction in 4000 hrs of testing at a working pressure of 140 kg/cm² (1991.26 lb/in²) and a temperature of 300°C, and is still in continuous service. In Fig 8 two typical corrosion curves for zircaloy-2 specimens subjected to different forms of heat treatment are plotted as examples of the results obtained so far in the water circuit.

The Advanced Gas-Cooled Reactor is the first to use the matrix-type co-ordinate sampling



Burst slug detection in the AGR

by *DAVID IGGULDEN, B.Sc., Technical Editor,* Nuclear Power

OPERATIONAL experience of the Calder reactors has provided a certain amount of information on burst characteristics and fuel behaviour. This experience could not be regarded as particularly valuable for AGR although, to some extent, it has aided attempts to predict the behaviour of oxide fuel and beryllium canning. The problematical nature of this behaviour demanded a b.s.d. system flexible in operation and readily adjustable to changing ideas. The Plessey precipitator operating in the b.s.d. systems of all the Calder reactors is the unit on which, at the present time, all practical experience is based. This relies on the principle of precipitation of the solid daughters resulting from the decay of gaseous Kr and Xe fission products.

This method was not automatically accepted for AGR and consideration was given to at least one alternative. It was not unreasonable considering the character of AGR, and the substantial differences between the proposed fuel and that in a 'magnox' reactor, to review possible new methods.

In addition to precipitators, the Plessey equipment for the b.s.d. systems of the Calder reactors includes 54-way selector valves. These valves permit gas samples from the fuel channels to be scanned in groups of four. By definition, this has obvious shortcomings in that particular events which occur while a channel is not being monitored may go unnoticed until a later and possibly more critical stage.

Because of the reserve of sensitivity in the precipitator system, it became possible — after Calder Hall — to parallel more than four reactor channels for sampling.

Considerable effort has also been devoted to decreasing the staggering amount of piping required if a sample from each of a large number of fuel channels is to be brought through the biological shield. The financial rewards brought about by even small savings per channel have encouraged many novel ideas. One of these is the matrix system of sampling. This begins to be attractive from a practical standpoint as the number of channels grouped for gas sampling reaches double figures.

WHAT THE SYSTEM DOES

- the 253 fuel channels of the AGR are grouped in a 16 × 16 matrix
- continuous monitoring of the matrix allows immediate detection of a burst
- the position of the burst is shown by lights on a presentation panel which is a replica of the core
- flexible controls provide variation in count and soak times
- indication of any faults in the system is provided

CONTINUOUS MONITORING — THE MATRIX

For a reactor of any size, it is obviously impracticable with current systems and equipment to monitor every fuel channel continuously. To reduce the number of monitors to an acceptable level, Channel samples are first grouped and then sequentially scanned. It has already been said that this can have certain drawbacks whereas, by continuous monitoring, the detector is able to present an unbroken history of fuel behaviour. Precipitator parameters, notably soak and count times, may be varied to seek preferential methods of monitoring without affecting the basic safety function of the system.

Continuous monitoring can effect almost immediate detection of a fault once increasing activity has risen to an observable level above normal background. The matrix method offers immediate location of the affected channel. Continuous monitoring of a matrix system of grouped channel samples thus presents an impressive arrrangement.

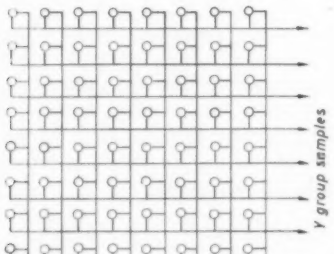
A typical matrix array is illustrated in Fig. 1. In the example, 64 channels are included in a piping arrangement which connects channels in groups of eight. One of the principal advantages of the matrix system is in the considerable reduction of pipework. If the matrix array can be installed near the core, the amount of pipework carried through the biological shield is immediately reduced by a factor equal to twice the number of sample pipes grouped or connected to one manifold.

At the same time this presents a problem of contaminating one or more manifolds with fuel particulates. If manifolds so affected are in a region of neutron flux, fission could occur with the result that background signal will rise considerably masking an otherwise observable increase in any of the channels connected to the same manifold.

In theory it is clearly possible to arrange the matrix manifolds outside the main reactor vessel. The manifolds are then more accessible for decontamination, and the

direct channel pipework connexions are available for blow back if necessary.

Apart from the cost, the principal disadvantage of such an arrangement is that in long pipework runs from the channel to the manifolds variation in pressure drop may easily occur unless special precautions are observed. Variations in mass flow of samples contributing to the group then follows with subsequent difficulty in assessing the implications of rising counts from the group sample. This difficulty is avoided if the manifolds are placed above the core near to the sample take-off points from the fuel channel. In the case of AGR the matrix pipework is arrayed in the hot-box where — even if perhaps with considerable difficulty — it is accessible, and shielded from neutron flux. This latter feature overcomes the objections of fuel particles in the manifold undergoing fission, and causing constant high background count from the monitor associated with that group.



An 8 × 8 matrix arrangement for 64 channels. Each channel has two independent connexions which are carried to different manifolds, one an 'X' ordinate, the other a 'Y'. Thus a burst occurring in any channel will cause high count readings in two groups which will immediately pin-point the location (Fig. 1)

The number (253) of fuel channels in AGR is particularly convenient for forming a 16×16 matrix array. The number of channels to each group (16) is not too high for a reasonable precipitator sensitivity to be achieved. Even so, the design of the monitor was not easy because of the need to work with sample mass flow rates very much lower than previously encountered in order to keep heat losses in driving the system to an acceptable level. In addition to this comes the problem — again the cost factor — of a comparatively large number of precipitators. One for each of the 32 manifolds.

THE PLESSEY 8-WAY PRECIPITATOR

The functional requirements of precipitators for AGR was that they should be effective in detecting every kind of burst that can occur. They were to operate in the conventional manner and should be compact. The development staff at Plessey Nucleonics carried out an extensive programme of analytical work into all aspects of the b.s.d. system and this resulted in the Mark 6, 8-way precipitator — a conventional machine in principle, but incorporating in a compact pressure vessel 8 precipitation and counting channels (Fig. 2).

Precipitation chambers are mounted in pairs equally spaced on a pitch circle inside a pressure vessel made from a solid billet. Flat plate covers are fitted at each end. One end of the vessel is almost solid. This section of the billet is used as shielding for 8 scintillation counters which are also arranged in pairs to correspond with the precipitation chambers.

Each pair of chambers and counters has its own wire and this is stored on pulleys at one end of the equipment. Shunt pulleys at the opposite end simply reverse wire direction so that it may return to the storage pulleys for a delay period before re-use.

All wires are moved simultaneously through gearing which is driven by a rack. The rack is reciprocated by a pneumatic actuator housed inside the pressure vessel and working from a clean CO_2 supply. Mechanical locks limit the motion to the exact indexing length between the chambers and the counter. The counters are similar in principle to those used in the precipitators for the Calder reactors but incorporate modifications to the scintillator aimed at improving the sensitivity to beta particles. A purging flow of clean CO_2 is supplied constantly to the phosphor region of the counter.

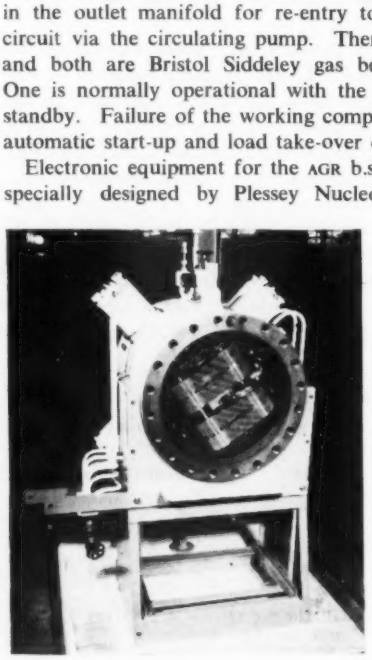
The AGR precipitator operates at full reactor pressure. Gas samples enter each precipitation chamber separately and flow to a common exhaust. The equipment is mounted on a stand which also houses individually adjustable E.H.T. supplies for the eight photomultipliers and an E.H.T. supply for the precipitation chambers.

PLANT ARRANGEMENT

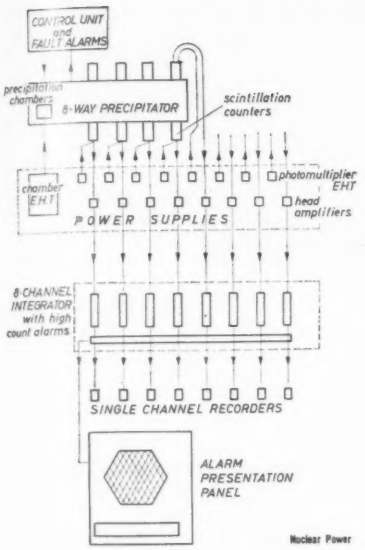
The precipitators for the AGR b.s.d. system are located in the plant room inside the containment. There are four 8-way units — grouped in two pairs — for monitoring the reactor core. Sample pipes from the reactor enter the room above floor level. The pipes are in two groups, one group for each set of ordinates in the matrix, and they are connected to multi-way shut-off and diversion valves — one for each pair of precipitators. The multi-way valve is used to divert gas samples from one precipitator to another and in this way continuity of monitoring is provided in the event of failure of one precipitator in a pair. The equipment can thus provide full safety protection with only half the monitors in service but this obviously reduces the ability of the equipment to pin-point the location of any high count channel.

After filtration the gas is passed to the separate chambers in the precipitators for monitoring and then combines in the outlet manifold for re-entry to the main coolant circuit via the circulating pump. There are two of these and both are Bristol Siddeley gas bearing compressors. One is normally operational with the second acting as a standby. Failure of the working compressor results in the automatic start-up and load take-over of the standby unit.

Electronic equipment for the AGR b.s.d. system has been specially designed by Plessey Nucleonics to meet the



The Plessey Mark 6, 8-way precipitator viewed during assembly (Fig. 2)



Block diagram of the instrumentation for the b.s.d. system, this is one of four units which feeds into the presentation panel (Fig. 3)

specific requirements of the plant. Again, reliability with economy has guided the development. Where possible, all equipments have been fully transistorized and a unitized system has been followed in the build-up of the various multi-channel units which operate with the 8-way precipitators. A power unit is located with each of these. This provides E.H.T. for each of the precipitation chambers and variable E.H.T. supplies for calibrating and operating the counter photomultiplier tubes. The amplitude of the output signal from these is sufficient without further voltage amplification before the integrator but the power unit includes eight head amplifiers for matching into the cable run from the plant room to the control room where the integrators are placed. There are four of these units in the control room. Figure 3 shows the instrumentation block diagram for one unit. Each has eight integrating channels with eight separate high count alarms. A meter on the front panel of the equipment may be switched to any of the eight channels to read integrated counts during the count period. The integrator has six ranges set between 100 and 300,000 giving a maximum count rate of 20,000 counts/s. The output from the final amplifier stage drives a single channel recorder of which there are thus 32 in all; one for each of the separate group samples. Recorders are sited in the control room.

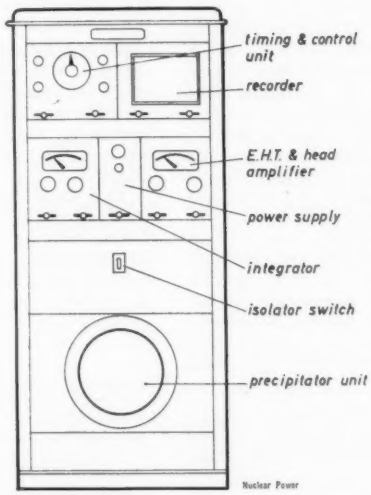
The system of high count alarms involves a subtraction circuit built into the integrator chassis. The output from eight integrating channels is averaged and subtracted from each separate integrator output before this is compared with the pre-set alarm level. This is an attempt at making the alarm signal independent of changes in overall background activity of the coolant and variations in reactor power. For the possible severe burst where background may rise at almost the same rate as the signal from any one group a protective alarm level is provided on each recorder.

High count alarms are relayed to a presentation panel which is a replica of the layout of channels in the core of AGR (picture at the top of p.71). A separate window represents each fuel channel and, under High Count Alarm conditions, this is illuminated by two lamps. It will be understood, from the arrangement of the matrix system of sampling, that a channel containing a burst element will cause High Count Alarms in both group samples to which it contributes. These two alarms will completely illuminate the presentation panel window representing the affected channel.

Controls and fault alarm indication for the Precipitators, Integrators and Recorders are provided by a single unit housed in the control room. Considerable flexibility in control is required to provide the adjustments to precipitator parameters which have been mentioned earlier. Complexity in the timer unit is almost unavoidable with such requirements forming the specification but the Plessey timer has at least sought to ensure mechanical reliability. It is motor driven with a master shaft capable of operating several others through a gear train and a series of clutches. Variation in soak (precipitation period) and count times may be selected by switches which set the timer to control the monitor and instrumentation to the pattern required. A standby timer is installed for immediate change-over in the event of failure of the operating unit.

AUXILIARY b.s.d. EQUIPMENT

Single way Plessey Mark 7 precipitator units, modelled on the Mark 6 equipment, have been developed for this purpose. Five of these units are wall mounted in the plant room for monitoring the reactor test loops. An additional rack in the same room provides the E.H.T. supplies, head amplifiers and timer units for these monitors with the integrators and recorders located in the control room.



Schematic of the Mark 7 precipitator and console used for the test loops and the reactor fuelling machine (Fig. 4)

Figure 4 is a schematic illustration of the Mark 7 precipitator and console which is mounted on a platform of the fuelling machine. The precipitator is installed near the base of the console with all the associated instrumentation mounted in the same rack. A similar set of equipment is arranged on a portable trolley with the addition of a small Corblin pump; this is used for monitoring single channels in the core. It may be moved readily about the pile cap and attached by flexible hoses to extract a continuous gas sample from any selected channel.

Acknowledgment
Thanks are due to the staff at Plessey Nucleonics Ltd for supplying material and their help in answering many questions.

A design project for a second reactor at Grenoble with ten times the power of Melusine has now been completed. Construction is due to start this summer with completion eighteen months later.

The Siloé reactor

THE CHOICE of a swimming-pool reactor with a power of ten megawatts represents a large increase over the power of existing French pool-type reactor group under G. Denielou at designed for an initial power output of one megawatt, and can be pushed up to two megawatts under present conditions.

Several swimming-pool reactors with open cores are operating at 5 megawatts abroad. They include the Sao Paulo (Brazil) reactor; DR-2 in Copenhagen; and I.R.L. in the USA. No special difficulties have been reported. At present several 10 megawatt pool reactors are being built or are at the design-study stage. Examples are ASTRA in Austria and the projects ANTR and AFN-ETF in the USA.

Difficulties

An increase in the power of a swimming-pool reactor cannot, however, be made with impunity, and two major difficulties will have to be overcome by the reactor group under G. Denvielou at Grenoble. Radioactivity at the surface of the water could well prevent access to points vertically above the core if no supplementary precautions were taken, and to reduce it to the permitted level of 7.5mr/h it is planned to set up a descending convection current by feeding in hot purified water at the surface and — possibly — by using a baffle. A study contract has been given to SOGREAH to solve this problem.

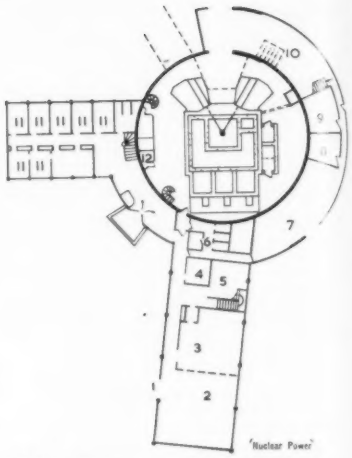
A circuit taking from one to two thousand cubic metres per hour has had to be worked out for Siloé and at one time cavitation in the pumps was feared. However a thorough study has now been carried out and it has been decided that these fears are groundless.

The reactor will be housed in a cylindrical concrete hall having as few openings as possible to give maximum containment. Two adjoining wings will house offices, laboratories, machinery rooms, control rooms, etc., the longer wing having two floors and the shorter three (see Figs. 1 and 2). There will be only one possible operating position for the core, whereas there are two in Melusine. Likewise, while Melusine has five radial and one tangential channel, Siloé will have only two channels. This simplification will give better safety and more experimental flexibility for the CENG research workers who generally prefer to irradiate their set-ups under water rather than place them in radial channels.

- **Versatility** The reactor is designed for use on all projects ranging from pure research to reactor technology.
- **High flux** Some experiments needing a year with Melusine will take only a month with Siloé.
- **Standardization** Fuel elements, control rods and operating mechanisms are based on Melusine and Triton.

The demineralized water will flow downwards through the core and flywheels will be connected to the pumps of the primary circuit to ensure adequate cooling for about 30 seconds in case of a complete electrical failure. Heat extraction will be ensured by cooling in a secondary circuit water pumped from the lower levels of the pool. No contamination of the latter is to be expected as both circuits are completely separate.

Five boron carbide rods will control the reactor. Their actuating mechanisms will be suspended from a sort of 'diving-board' fixed to the upper section of the pool. A study is being carried out on the use of 'guillotine' bars designed to hold down a considerable amount of reactivity which would result in improved reactor safety.



1 Lorry entrance
2 Workshop
3 Electrical services
4 Office
5 Store
6 Hot change rooms
7 Air purification
8 Compressors
9 Compressor services
10 Coffins
11 Staff rooms
12 Storage

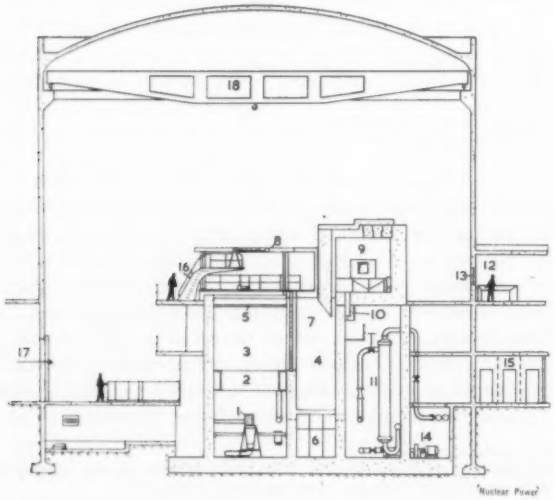
Plan of the ground floor (Fig. 2)

MAIN DATA

Type: Light water pool reactor.
Thermal output: 10 MW.
Fast flux (Max.): 10^{14}n/cm²s
Fuel elements: 18 plate MTR type
Fuel: Al/U alloy.
Enrichment: 90%.
U-235 per element: 196 g.
No. of fuel elements: 25.
Pool dimensions: 4·6 × 4·6 × 10·5 m.
Control: 5 boron carbide rods.
Reflector: H_2O.
Containment: 24·8 dia. 23 m. high

Twelve experimental positions laid out on two floors are foreseen for the use of workers, who always need a lot of space for the control mechanisms of their loops or irradiation thimbles. From these positions, the cables and tubes will run to a sort of metal 'spider' two metres above the pool before plunging down towards the core. A or hot cell with direct access to the pool is also foreseen.

As Melusine has two working positions it is proposed to erect in one of them a core identical with that of Siloé. Low-power measurements will thus be carried out in Melusine saving an appreciable amount of the time which would normally have been needed for Siloé's approach to maximum output.



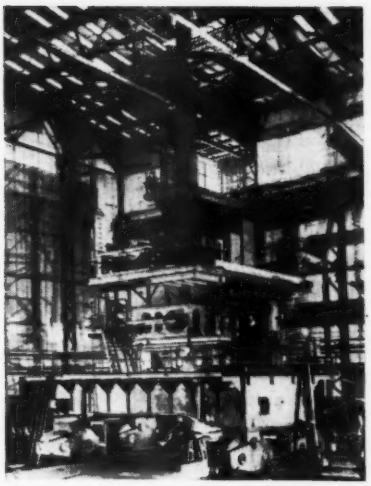
1 Core
2 Diffuser
3 Pool
4 Work pool
5 Hot water feed
6 Storage coffins
7 Caisson
8 Metal spider
9 Hot cell
10 Emergencyprotection
11 Cooling systems
12 Control room
13 Viewing port
14 Mocor pumps
15 Hot storage rooms
16 Viewing gantry
17 Lorry entrance
18 12-ton crane

Section through the reactor building showing the arrangement of core and experimental facilities (Fig. 1)

Building this machine, one of the largest of its kind, has presented some interesting design and fabrication problems

Refuelling the AGR

by J. SPENCER BURKETT, Assistant Editor, Nuclear Power



Main construction work on the AGR refuelling machine is complete and proving tests are being made at Markham's Chesterfield works (Fig. 1)

IN ITS FINAL STAGES of construction, the refuelling machine for charging and discharging the Advanced Gas Cooled Reactor at the UKAEA, Windscale, is designed for automatic positioning over any of the selected 253 charge tubes to within 0.005 in. The machine is independent of all extraneous mechanical aids and will travel the full floor width of the containment building. In addition to working under the normal conditions of full load and pressure, facilities are available for inspection and maintenance of the reactor core during shut-down.

Main Structure

The principal features are the gantry which enables the machine to travel the reactor floor, a crab that allows the operating part of the machine to traverse the gantry, and a high superstructure that houses the Normal Handling Facility and the Special Handling Facility. The crab also supports the control platform, beneath which the cooling and purge system is housed. (Fig. 3).

Constructed in four sections to allow reconstruction in the AGR containment building, the gantry consists of two main girders connected at each end by transverse girders, each of which is fabricated from plate with a box form cross-section. The four double-wheeled bogie units that support the gantry structure, through centre trunnions, run on double-flanged cast steel wheels and roller bearings, with rails of 375 16 s/yd standard rail section.

The gantry is driven by two 5 hp 1500 rev/min d.c. motors each coupled direct to a triple reduction spur and helical gearbox. These in turn are connected to the main gear train by flexible couplings which allow limited angular and lateral shaft misalignment but retain torsional rigidity. The main gear train, one of which is positioned on each side of the gantry, consists of two sets of bevel gears and a final reduction of spur gears on to the wheels of the driving bogies. The first reduction bevel wheels of each train have additional mating pinions to interconnect the two drives through a synchronizing shaft, again using flexible couplings to give flexibility of shaft alignment whi'st retaining torsional rigidity. An 'emergency' hand-operated worm drive is provided which can be clutched into engagement, if necessary, and this drive is taken into the main gear train by a third pinion meshing with the first reduction bevel wheel on one side of the gantry.

An essential feature of the main gear trains is the minimum of backlash, and to achieve this the gears have been cut to Class A accuracy with a maximum of 0·002 in backlash/mesh. Provision has been made for adjustment to compensate for any gear-tooth wear. The total backlash obtained over the full gear trains of around 2000/1 is well within the specified maximum of equivalent to 0·005 in at the driving bogie wheel. The maximum gantry travelling speed is 10 ft/min and steady running speeds as low as 0·006 in/min have been achieved, thus facilitating fine positioning.

By 1965, *some sixteen charge machines will be in operation, servicing under on-load conditions a variety of power and experimental reactors:* NRU (1957), AGR (1961), *Bradwell* (1961), *Berkeley* (1961), NPD (1961), EDF-2 (1962), *Hunterston* (1962), *Hinkley Point* (1962), EGCR (1962), *Latina* (1962), *Trawsfynydd* (1963), MSRE (1963), CANDU (1964), *Dungeness* (1964), *Tokai Mura* (1964), *Sizewell* (1965). *Of these, only six are combined-purpose machines and the biggest are those for the* AGR, *Bradwell and Tokai Mura.*

Total weight	400 *tons*
Height	65 *ft*
Total shielding	200 *tons*
Working pressure (on load)	280 *lbf/in²*
Design temperature	325°*C*

The crab

This is constructed in one piece from box cross-section girders and the bogies carrying the crab are very similar to those on the gantry. The centre of the crab is ovoid shaped to allow the pressure vessels of the handling facilities to pass down through the crab to the reactor floor below.

The crab drive is similar to the gantry except that two 2 hp 1000 rev/min d.c. motors are used to give a maximum traversing speed of 4 ft/min. The weight of the two handling facilities and their associated shielding, together weighing over 200 tons, is transferred to the crab by means of a support structure that sits on the top of the crab. Below crab level it takes the form of a fabricated cannister, ovoid in section, into which is fitted the cast iron shielding. (Fig. 4.) Above crab level, this ovoid shape continues up to the grab access platform level where it becomes cylindrical in cross-section. This then extends to the level of the top platform where the support for the normal handling pressure vessel is provided.

The lower detachable shield and shielding doors, attached to the bottom of the support structure, are for maintenance and for easy access to the nose units. The 'Jabroc' laminated wood, used as fast neutron shielding, is attached to the outside of the support structure.

Normal handling facility

Designed for 500 lbf/in², the pressure vessel that houses this facility is con-

structed from seamless tube, 23 in o.d. and 1⅛ in wall thickness. Each section has forged steel flanges bolting together forming one long vessel. (Fig. 5.) Most of the flanges forming part of the pressure circuit which are seal welded, and all the other pressure parts, are fabricated from steel with an impact value of at least 35 ftlb at —10°.

The lower end of the pressure vessel is formed from a heavy steel forging. The cooling circuit pipework is connected at this point to the main pressure vessel as is also the small pressure vessel that houses the television camera, used for viewing the fuel stringer entering or leaving the machine.

Fitted beneath the 'bottom end forging' is the retractable nose unit consisting of two concentric tubes, arranged to slide in a telescopic fashion when driven by a motor and gear unit. The inner tube has two chevron type seals, one of which connects with the fixed tube and the other with the reactor stand-pipe when it is in the extended position. Gas is ducted to this seal for cooling. The nose unit also carries a sensing head for fine-positioning the machine.

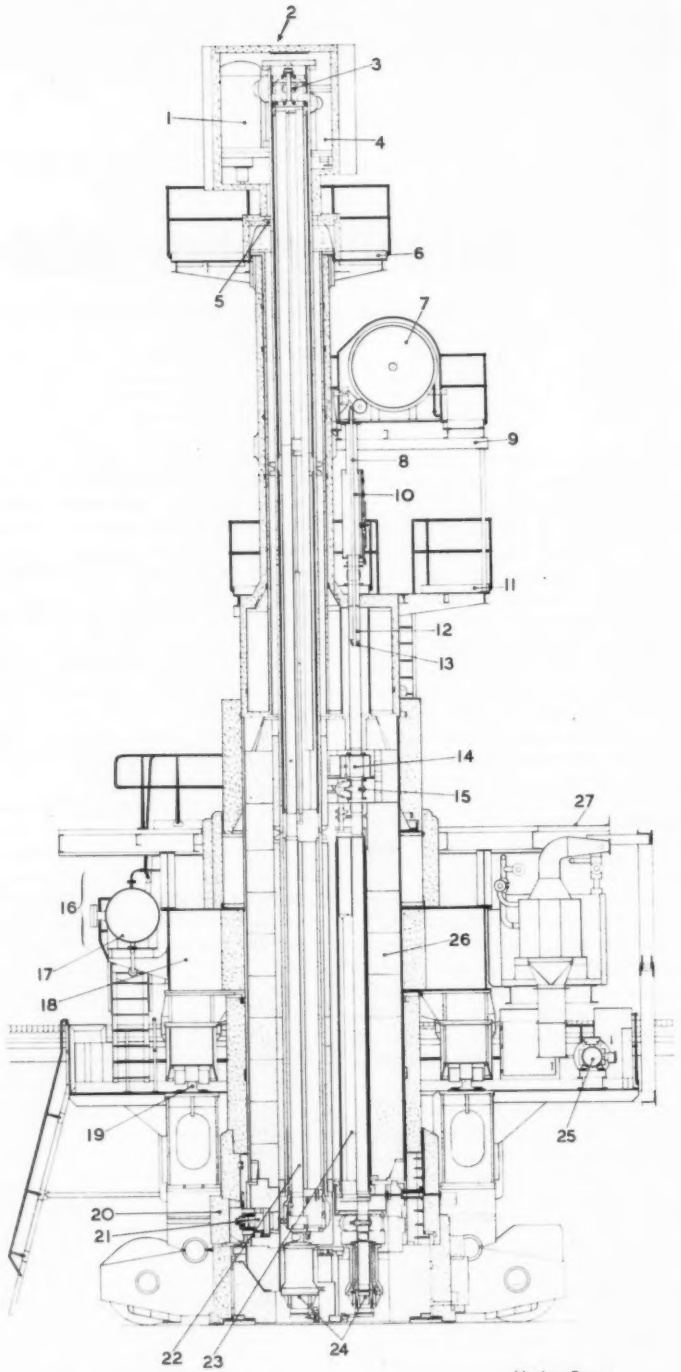
When the machine is detached from the reactor, the pressure boundary is made by a seal plug that seats into the fixed section of the nose unit. The plug is coupled to the fuel element with a connector unit and connected at the top with a chain for raising and lowering. The seal plug also houses an emergency brake in case of chain breakage and gives access to the thermocouple compensation leads used for measuring fuel element temperatures. These leads connect to cables which run via the chains to the control console.

The normal handling vessel contains a rotating magazine with three compartments, each being formed by a stainless steel tube running the full length of the magazine. (Fig. 5.) They house the new fuel element, the irradiated element and a stand-by reactor seal plug. The weight of the magazine is taken by a bearing supported from a plate inside the pressure vessel.

Three small pressure vessels at the top of the main pressure vessel house the operating equipment for the normal handling facility: electric motor and gear boxes for magazine rotation; the magazine lock for safe operation; and the winch drive operating the chain sprocket.

Special handling facility

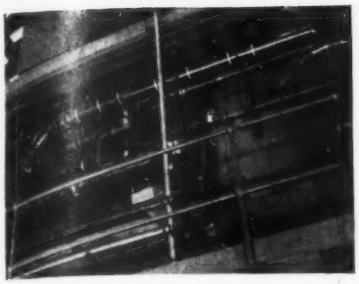
Used only when the reactor is shutdown, this facility is primarily for reactor core inspection and the emergency removal of damaged fuel elements. These operations are assisted by a combined television camera and grab unit. The latter is suspended from a



Nuclear Power

The AGR refuelling machine, designed and engineered by John Brown (S.E.N.D.) Ltd to UKAEA Specifications (Fig. 2)

1 winch drive
2 magazine drive (not shown)
3 winch drive sprockets
4 magazine lock
5 main pressure vessel support flange
6 platform for maintenance and emergency hand winching, etc
7 television hose drum
8 television hose
9 special handling winch platform
10 grab access box
11 special handling grab access platform
12 television camera
13 grabs (shown withdrawn)
14 shielding block in place
15 gate valve
16 cooling circuit equipment
17 purge tank
18 crab structure
19 crab rails
20 'Jabroc' fast neutron shield
21 television camera
22 NORMAL HANDLING FACILITY
23 SPECIAL HANDLING FACILITY
24 Nose units retracted
25 gas bearing circulators
26 cast iron shielding
27 control platform

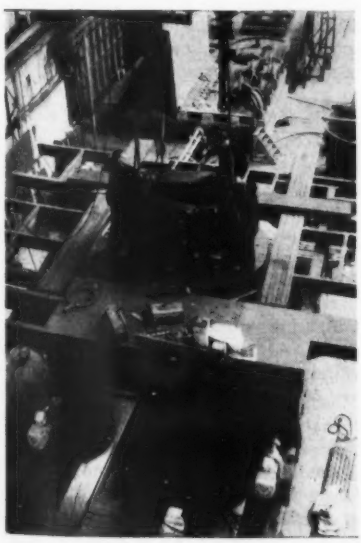


The cooling circuit valves under the control platform (Fig. 3)

flexible metal cable that contains the TV grab electrical cables, and an annulus through which clean CO_2 is passed to cool the camera unit.

The camera winch is also housed in a pressure vessel and this is connected to the special handling vessel by a tubular section that incorporates an access door, to allow the grab tools to be changed, together with an isolating valve and shield block. These are interlocked in such a way that the access door can only be opened when the shield block is in position, and the valve is closed to isolate the grab access box from the pressure circuit. The box is purged before opening.

The special handling vessel also houses a three-compartment rotating magazine. When the channels are positioned over the operating centre line, a through passage is provided for the TV camera. The retractable nose unit is identical with that on the normal handling vessel. Because the special facility works only at low pressure, it has been designed for 25 lbf/in². To prevent the full reactor pressure being applied,

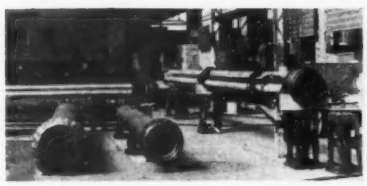


Lowering the cast iron shielding during construction (Fig. 4)

all cooling pipes have a section removed and terminate in a stop valve and blank flange. Before the facility is brought into action these have to be removed and the section of pipe inserted.

Cooling circuits

As soon as the spent element reaches a pre-determined height within the machine, the latter takes over the cooling of the element until it is discharged from the machine. A cooling circuit is therefore built into the machine that also provides CO_2 for the nose unit seal cooling. Heat is removed by an air-cooled heat exchanger which rejects the heat into the containment building. In the event of a cooling fan failure, a second is provided and to prevent impurities in the cooling gas from being recirculated, a filter is



Pressure vessels for the two handling facilities and the three-compartment magazine before installation (Fig. 5)

installed within the circuit. The filter case is surrounded by a thick cast iron shield. Two gas-bearing circulators are provided, one acting as stand-by. In the event of a failure, a changeover valve is immediately operated to bring the stand-by unit into action. By the use of pneumatically operated valves the cooling circuit can be isolated from the normal handling facility when the special handling facility is in use.

Temperatures, pressures and flows are indicated and recorded on the main control panel from a number of points in the circuit. High temperature and pressure conditions, together with low flow, actuate an annunciator alarm system.

All the valves in the circuit have bellows seals and, wherever possible, all flanges are seal welded to reduce leakage. All pressure parts are designed to 500 lbf/in² and to Class I standards.

When the nose unit is connected with the reactor it is purged with CO_2; after refuelling it is purged with air. To do this the machine is fitted with separate purging equipment. A vacuum is created on the nose unit by means of diaphragm compressors which discharge into a storage tank via a non-return valve. The contents of this tank are stored and discharged later at a gas disposal point. The nose is then filled with either clean CO_2 or air. The purging process is repeated several times until sufficient dilution is reached. Clean CO_2 is stored in bottles, air comes from a small compressor.

Safety circuits

The safety of the machine is ensured by the use of a lever locking frame provided with mechanical interlocking and electrical locks operating in conjunction with relays, detector switches, and motor locks or brakes. The safety equipment operates both on hand and motor control, hence the devices which ensure the safety of the equipment are arranged to be the motor brakes or locks. For all equipment within the pressure vessels motor locks are used so that the lock positions can be detected. Mechanical interlocking is used to ensure availability of coolant and to prevent winching after a failure of coolant flow.

Refuelling operation

After taking up a new fuel element, the machine is pressurized at 280 lbf/in²g with clean CO_2. Using coarse positioning the machine is moved over the selected refuelling branch; the fine positioning operation brings it to within 0·005 in. After opening the shielding doors, the reactor plug is manually connected to the machine, the doors then close.

The nose unit is lowered and then purged and pressurized with clean CO_2. The irradiated fuel stringer is then slowly hoisted into the magazine, the latter is rotated and a new fuel stringer is lowered into the reactor. The nose is purged with air and the unit is retracted. The shielding doors are again opened to disconnect the reactor plug. The machine is then driven away to the spent fuel disposal hole, purged and depressurized before recommencing the cycle of operations.

MAIN CONTRACTOR

JOHN BROWN (S.E.N.D.) LTD *design and engineering*

PRINCIPAL SUB-CONTRACTORS

JOHN BROWN GROUP: MARKHAM & CO. LTD. *main mechanical sub-contractor;* AUTOMATIC CONTROL ENGINEERING LTD. *control panel;* JOHN BROWN (Clydebank) LTD. *detachable shielding.* AITON & CO. LTD. *pipework;* G. ANGUS LTD. *main gears;* BALDWIN INDUSTRIAL CONTROL LTD. *pneumatic equipment;* BRITISH INSULATED CALLENDERS CABLES *cables;* BROOM & WADE LTD. *air compressors;* B.T.R. INDUSTRIES LTD. *leaded rubber shielding;* COLVERN LTD. *positioning heads and safety switches;* CONTACTOR SWITCHGEAR LTD. *motor starters;* C.T. (London) LTD. *Corblin CO_2 diaphragm compressors;* DEWRANCE & CO. LTD. *CO_2 valves;* DOWTY TECHNICAL SERVICES LTD. *gas bearing circulators;* FLIGHT REFUELLING CO. LTD. *telescopic connector units;* K.C.V. PRECISION TOOL CO. LTD. *special gear units;* LINTOTT, H. & E. LTD. *test and training channels;* MAWDSLEYS LTD. *electrical machines;* MAX-SEAL VALVES LTD. *CO_2 valves;* MUIRHEAD & CO. LTD. *Magslips;* OPPERMAN GEARS LTD. *gear boxes;* PERMALI LTD. '*Jabroc*' *fast neutron shielding;* POWER AUXILIARIES LTD. '*Plessiflex*' *hoses;* PYE T.V.T. LTD. *television equipment;* RENOLD CHAINS LTD. *winch chains;* SANDERS LTD. *distribution panel;* SENIOR E.X. '*Kabelschlepp*' *installations;* TINGEY & CO. LTD. *special handling winch and sundry mechanical details;* J. WALKER & CO. LTD. *seals;* WELLINGTON TUBE WORKS LTD. *heat exchanger;* WESTINGHOUSE BRAKE & SIGNAL CO. LTD. *lever frame and relay rack*

Here is 'Nuclear Power's' quick reference guide to interesting equipment for the nuclear engineer

Engineering, Marine, Welding and Nuclear Energy Exhibition

Olympia, London, April 20 - May 4

THE ENGINEERING, MARINE, WELDING and Nuclear Energy Exhibition this year demonstrates the ability of the engineering industry to meet difficult specifications in numerous 'one off' type jobs. It also shows the value of work completed for government sponsored bodies—the 'know-how' gained is applied later to production line work. From some of the hardware exhibited, it is clear that certain industries are not content to sit back after the successful completion of a specialized project, but have looked further afield for a wider application. The exhibition also demonstrates the close interdependence of the many engineering fields—chemical, electrical, marine and nuclear; how the successes of research and development in one field are passed on to others—this applies equally to materials, machines and ancillary equipment.

Nuclear equipment

Among the British exhibitors is **Babcock & Wilcox** (Stand G4) with models of nuclear steam raising plant for the 580 MW Sizewell nuclear power station. The CEGB Berkeley high activity laboratory, that will receive for examination irradiated fuel elements from the nuclear power stations, can be seen as a scale model on **Hobson's** stand (Outer 7), the firm responsible for design and manufacture. **Short's** (Stand Outer 11) are featuring their simulator for the Calder Operations School; it has a capacity of 200 amplifiers and an overall component error of $< 0{\cdot}1\%$. Exhibiting for the first time, **AMF Ltd** (Stand Q8) are showing the tank type 5-12 MW research reactor, master slave manipulators—made under licence by Pye, and the new AMF-Maxim 'Aquavap' heat recovery evaporator that uses waste heat to distil fresh water from salt or brackish water. An Austrian firm, **Simmering-Graz-Pauker** (Stand K14) is also demonstrating its work in the research reactor field, including 80% of the mechanical components and the 500 hp diesel for the 5 MW Astra, and similar components for Vienna's 100 kW Triga.

Richardsons, Westgarth (Stand G7) who are supplying the generating, condensing and feed heating plants, and CO_2 circulators for Trawsfynydd, are exhibiting a new type of bellows restraint mechanism, a CO_2 blower rotor and a model of a cascade corner bend for the CO_2 circuit. Other new components for gas circuits are **Flight Refuelling's** (Stand Inner 26) remotely controlled inline shut-off valve for possible electrical failure, and a self-sealing hose coupling which can be connected and the valve opened against line pressure, with automatic 'throw out'. A fluid coupling of the Vulcan-Sinclair double-circuit scoop trim type, similar to the 16 sets installed at Berkeley for driving the 4000 hp CO_2 circulators, is to be seen at Stand H4 of **Fluidrive.** In addition to gas bearings and pumps, **Bristol Siddeley** (Stand P6/7) are demonstrating applications of their 6 in-30 ft ball screws and splines, used at Hinkley Point on the charge mechanism. **Teddington** (Stand Outer 13) have a range of isolation cocks for small bore instruments, designed for pressures up to 650 lb/in² and temperatures up to 450°C, with leakage across the seat of around 0·001 lb/h at 600 lb/in².

> Held every two years, and of increasing importance internationally, the Engineering Exhibition will this year represent over 500 firms and organizations. The whole field of mechanical engineering is covered from boilers, engines and turbines to filters, piping, pumps and valves, together with various ancillary processes. Nuclear equipment of one sort or another will be seen on some 40 per cent of the stands.

In addition to a control drive gearbox designed as an integral part of the Berkeley visual observation and removal equipment, **J. Thompson** (Stand F3) are showing their alternative to thicker pressure vessel walls—band reinforced vessels. The many uses of 'Plessifex' are represented on **Power Auxiliaries** stand (BB14) by fuel charging, b.s.d. and special television equipment applications. **Telektron's** control system, panels and equipment (Stand Outer 14) are shown as applied to the Berkeley discharge mechanism.

Among the nuclear exhibits of **Talbot Stead** (Stand Inner 34) are models of a stainless steel control rod with boron inserts; a mild steel charging stand pipe, whose upper part consists of a concrete-filled outer tube containing four inner tubes, whilst the lower part is made up of a large tube with a smaller tube attached to its outer wall; and a restraint tie bar. **C.A.V.** (Stand A8) are showing an electrically operated 18-position rotary selector gas valve, used for burst-slug detection. The main feature of **Darlington Forge's** stand (H15) is the 5 ton forged steel gas duct reinforcement ring, representative of those already supplied for Bradwell. Axial fans with slotted blades, similar to those fitted in American nuclear submarines, are being shown by **Keith Blackman** (Stand A1), who claim for them high efficiency and high operating pressures at low speeds, with a corresponding reduction in turbulence and blade friction, noise, size and weight.

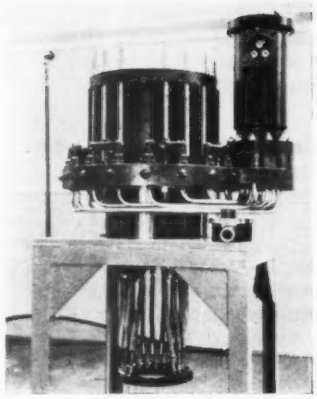
Among the irradiation units is the 'Gammacell 220' of the **Atomic Energy of Canada Ltd.** (Stand K16), that has a fixed source of up to 54 cobalt-60 rods arranged in squirrel cage formation round a 6 in dia. x 8½ in high irradiation chamber.

By means of four spiral tubes, gases and liquids can also be irradiated under flow conditions. Among the products from **Nuclear Enterprises** (Stand K16) are low-cost plastic phosphors with a high light-output efficiency; the 'Scintillometer', designed for airborne or land surveys and incorporating a large sodium iodide (thallium-activated) 3 in crystal and a 3 in Dumont photo-multiplier tube; and the 'Berylometer' scintillation counter for beryllium prospecting. Other exhibits include the transistorized counter, series 1000 Transcint; the 1020 air sampler; moisture meter, model 19; a slow neutron detector, NE 404; and flow cell, NE801, for monitoring effluents from ion exchange columns. **Plessey's** (Stand BB14) milk monitor incorporates two scales, each calibrated directly in infant tolerance levels, one from 0-3 and the other from 0-200. In addition to the Siemens 18 MeV betratron and the normal range of mobile X-ray units, **Pantak** (Stand Outer 14) are exhibiting the full range of portable Balteau units; including the 150 and 300 kV models, produced in special forms for 360° pipeline examination.

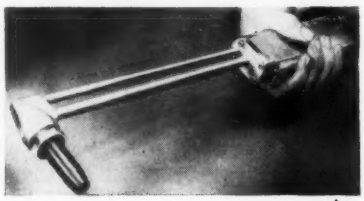
Heating and Cooling equipment

For Drakelow 'C', Britain's first power station to operate at supercritical steam pressure, pulverized-coal fired, forced flow, boilers from **Babcock & Wilcox** (Stand G4) and **International Combustion** (Stand K3) are to be supplied. Each boiler will supply steam at $2{\cdot}5^5$ lb/h to a 375 MW turbo-alternator set at a superheater outlet pressure of 3650 lb/in² and a temperature of 599°C. The latter firm is also featuring a sectioned scale model of the 550 MW boiler unit for the Thorpe Marsh power station. Power station boilers and associated equipment are also represented on **John Thompson's** stand (F3) and they show the design trend towards ever-increasing temperatures and pressures. New is the 'Demipac' packaged boiler covering the range of 500-2000 lb/h at 100°C. For outputs of 600 to 10,000 lb/h is the new 'Swirlyflo' Mk III boiler represented as a working model by **Spanner** (Stand D10). Among the water tube boilers and pressure vessels constructed by **Fraser** (Stand K8) is the radiant heat boiler, completely water jacketed, that has a design pressure of 70 lb/in². Suitable for cleaning shell and water tube boilers is the sootblowing equipment exhibited by **Aberdare Engineering** (Stand D13).

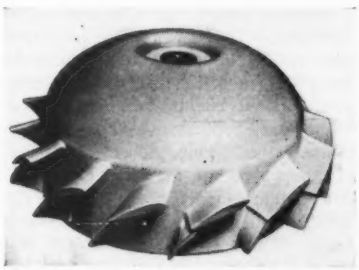
In the heat exchanger field, **ICI's** (Stand Outer 30) 'Integron' integral finned High-fin and Low-fin forms are represented by models of typical installations. **Clayton's** (Stand Inner 30) heat-exchanger tube, consisting of a continuous wire wound into elongated loops firmly bonded to a basic tube in helical formation, is now available without a centre rod. This is for applications where the rate of heat



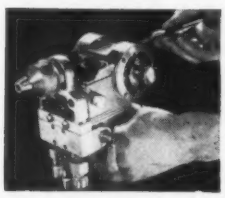
▲ FISSION PRODUCTS DETECTION—C.A.V.



▲ POWDER WELD TORCH—Deloro Stellite

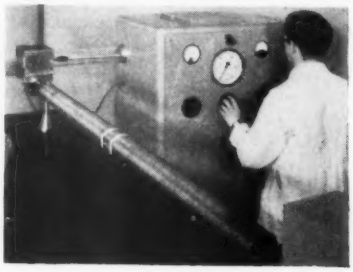


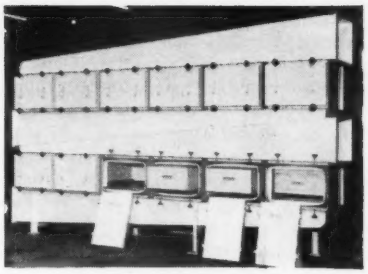
▲ AX-SLOT IMPELLER—Blackman



◀ SPRAY GUN—Metallisation

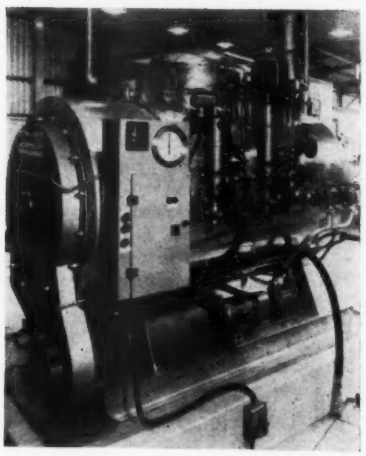
FATIGUE TESTING MACHINE—Stewarts & Lloyds ▼



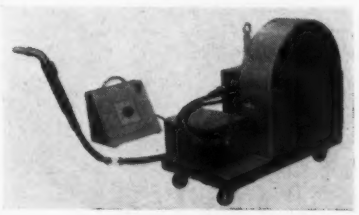


▲ 'UNIPAK' FILTERS—Vokes.

▲ DIDO CONTROL GEAR BOX—Hobson



▲ 'SWIRLYFLO' BOILER—Spanner



▲ ARC WELDING UNIT—Lincoln Electric

exchange and fluid pressure drop are critical. For gas compressor intercoolers and gas turbine use, **Spiro-Gills** (Stand N1) are showing their ripple finned tubing, originally developed by Escher Wyss. For the heating and ventilating engineer is the range of spiral tube electro unit heaters from **Spiral Tube** (Stand A17), covering 2, 3 and 5, 7 and 10 kW. **Tubes Ltd** (Stand A12) are showing their extended surface high and low pressure superheater tubes, to be used at Trawsfynydd.

In addition to 'Fin-fan' air cooled heat exchangers, packaged boilers and other equipment, **Head Wrightson** (Stand Inner 7) are demonstrating typical 'Counterflo' induced-draught cooling towers that use the new polethylene or polystyrene packing. Other water cooling specialities, from **Film Cooling** (Stand Inner 33) include a packaged plant with resin-bonded glass fibre laminate shell; a model of a twin-cell induced draught concrete shell tower; and examples of coloured cement asbestos sheeting and timber cladding employed in various types of towers. The principal exhibit of **Bennis Thermoflash** (Stand Outer 10) is their flash-type water distillation unit, designed to use hot gas up to 538°C (or nuclear heat source) and capable of operation unattended for long periods. **Weir** (Stand F2) are also showing evaporator units.

For heat insulation, asbestos is well represented by **Cape Asbestos** (Stand BB2) with the 'Caposite' amosite variety, as used at Berkeley around the pressure vessels, and the 'Rocksil' mineral wool, used for the outlet gas ducting. **Turner & Newall** (Stand DD8) are displaying their sprayed 'Limpet' asbestos insulation. Pipework insulated with 85% super-magnesia, Paratemp and Dextramite is the feature of **Chemical & Insulating's** stand (L4). Paratemp, highly resistant to weather effects, can be used in the range 93°-790°C; Dextramite up to 1093°C. For low temperature work is the polyurethane foam of **Newalls** (Stand DD8) that can be poured as a liquid mix into cavities of complex design or difficult of access.

Pumps, blowers and filters

The latest addition to **British Labour's** (Stand P3) range of UPL and UHL self-priming pumps is the type 60 available for capacities up to 1100 gal/min with heads up to 150 ft. **Dowty's** (Stand BB10) Vardel pump is a high pressure piston type unit for applications requiring hydraulic pressures up to 4000 lb/in². The output at 1500 rev/min is 2·4 gal/min. For wet and dry vacuum services, **Drysdale** (Stand H7) are showing the 'Aquair' rotary vacuum pump of the water ring type. Their 'Capsule' axial flow pump is designed for circulating oil in oil-cooled transformers. With a speed range from 500 to 3000 rev/min, **Goodyear's** (Stand DD4) new B12 pulseless axial flow unit is capable of handling a wide variety of chemical products from low to high viscosity. The main exhibits shown by **Gwynnes** (Stand Q5) are large pumps for power stations and sewage works. A cooling water type is included that has been designed for 9000 gal/min against a total head of 22 ft at 495 rev/min, driven by a 95 hp motor.

New designs or new developments from **Hamworthy** (Stand F13) include the vertical centrifugal 'Dolphin' pumps with capacities up to 2000 gal/min, a horizontal pump with capacities from 800 to 8000 gal/min, internal bearing screw pumps and screw rotary displacement pumps. **Hobson's** (Stand Outer 7) range includes the hydraulic pump, type 447, that delivers power up to 65 bhp at a fluid pressure of up to 2000 lb/in². Piston type units displayed by **Lucas** (Stand A7) cover outputs from 60 gal/h to 3000 gal/min with maximum pressures ranging from 3000 lb/in² to 5000 lb/in². Among the exhibits shown for the first time by **Worthington-Simpson** (Stand S4) is the 6L13 high-head centrifugal pump that delivers 920 gal/min of water against a total head of 440 ft and the 3D052 open impeller 'Monobloc' unit for handling slurries and viscous liquids at 360 gal/min, with a maximum head of 86 ft. Other pump manufacturers represented are **Tangyes** (Stand J5) with their new 'H' type high pressure double-acting reciprocating piston pump; **Lee, Howl** (Stand N2) with a new 'Hypersilid' centrifugal chemical pump; and **Mirrlees Watson** (Stand H10) with their range of electrically driven Leblanc rotary pumps, used for evacuating the condensers of large turbo-alternators in power stations. Epicyclic speed-reducing planetary gearings for nuclear power station pumps are exhibited by **W. H. Allen** (Stand D1) and include 1150 hp and 4000 hp units.

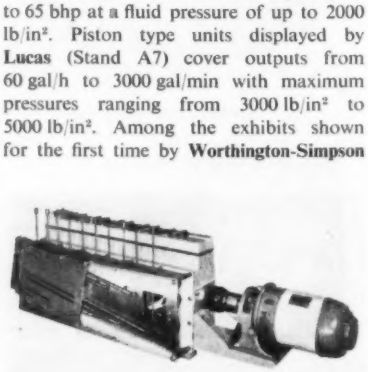
Blowers and compressors are also well represented this year. On the **Plannair** stand (Inner 21), among the special purpose blowers is a CO_2 circulator for test rig application. This unit, with its 11,500 rev/min motor is designed to work up to 300 lb/in² and at 350°C, with a mass flow range up to 8000 lb/h. Compressor manufacturers represented include **Reavell** (Stand C5), whose selection from 150 different types, includes air-cooled and water-cooled machines for pressures up to 4500 lb/in²g; **Broomwade** (Stand H8), with a range of air compressors having outputs from 3 to 525 ft³/min; **Holland Engineering** (Stand B5), who are demonstrating the advantages of their vane type units; **Godfrey** (Stand Inner 12), with the new type 220 screw type compressor that delivers 450 ft³/min at pressures up to 30 lb/in²; and **Wellworthy** (Stand Inner 19).

In the filter field, one of the main **Vokes** (Stand E4) exhibits is a model of the 'Unipak' system for housing multiples of their 'Absolute' filters. **Dallow Lambert's** (Stand BB3) dust control equipment covers the 'Unimaster' line. A wide range of industrial filters and strainers for most kinds of liquids and gases can be seen on the **Simmonds** stand (Outer 35). **Martonair** (Stand Outer 24) air-line filters of new design are available in ¼ in and ½ in BSP sizes. '**Auto-Klean**' filters (Stand D3) have many nuclear applications but of interest is the new element consisting of a fibre yarn wound on to a wire-mesh former that can be used in waste disposal lines. **Intermit** (Stand Outer 46) have a range of metallic and nylon filters, strainers and breathers.

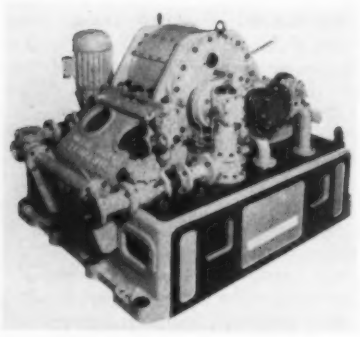
Valves, pipes and seals

A new type of automatic starting air valve for diesel power plant, designed by the UKAEA, is on show by **Pyropress** (Stand Inner 4). In the latest version, spring loading supersedes weight loading. An interesting air flow valve from **Muntz** (Stand AA5) uses moving blades that return to their seats and seal when flow attempts to reverse. **Martonair's** new

BERKELEY GEAR BOX—J. Thompson ▶



BERKELEY SCOOP TRIM—Fluidrive ▼



◀ FLAW DETECTOR MK3—Ultra-sonoscope

range S700, ¾ in BSP, are designed for a pressure range of 30 to 100 lb/in² and a flow of 180 ft³/min at 80 lb/in². In the event of a broken coupling or pipe rupture, a new high-pressure shut-down valve shown by **I. V. Pressure Controllers** (Stand Inner 35) automatically closes off a system. In the chemicals field, **Newman, Hender** (Stand H9) are making under licence the 'Newman-Velan' valves in ranges up to 2 in. The gate type is designed for 600 lb/in² and 428°C; the globe type is primarily intended for high pressure/temperature service. The 'Kernon' valve introduced by **Harlow** (Stand Outer 38) uses a p.t.f.e. diaphragm and is intended for corrosive conditions. **Crane's** (Stand G10) range includes cast steel flex and wedge disk gate valves and the stainless steel wedge disk type 33. For steam flow control, **Copes** (Stand Outer 24) have a variable orifice desuperheater of novel design.

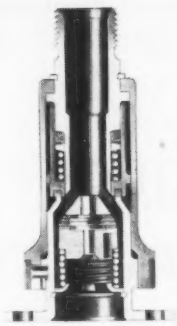
Control, servo and solenoid valves are represented by **Audco** (Stand Inner 26), **Maxam** (Stand Outer 5), **Lockheed** (Stand Inner 8), **Dowty** (Stand BB11), **Stein Atkinson Vickers** (Stand M8) and **Limitorque** (Stand Q4). The main exhibit on **English Electric's** actuator stand (Q6) is the new range of rotary electric actuators providing torque outputs from 80 to 800 lb/ft. Other valve firms at Olympia are **British Steam** (Stand G3); **Hydraulics & Pneumatics** (Stand S3), with a new range of remote control valves; **Goodyear** (Stand DD4); and **Saunders** (Stand R5).

Pipework for high pressure and temperature steam plant is one of the features of **Aiton's** stand (M7), particularly the 18 in corrugated piping for Trawsfynydd's CO_2 circuit. In addition, a scale working model demonstrates the operating principle of their 'Uniload' constant load pipe supports. **Teddington** (Stand Outer 13) are displaying a variety of stainless steel, butt welded bellows graduated in size from 66 in to 10 in dia. Other tube manufacturers include **B. K. L. Alloys** (Stand R1) with their special types of bends; and **Vokes** (Stand E4) with their 'Genflex' bellows expansion joints ranging from 3 in to 120 in dia. Pipe joints and couplings are included among the exhibits of **Alenco** (Stand Inner 45), **Keelavite** (Stand A16), **King Aircraft** (Stand Inner 14), and **Metalastik** (Stand Outer 11).

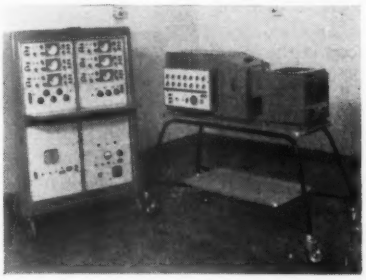
For gas sealing, **Crane** (Stand Centre 3) have a demonstration rig for their mechanical shaft seals. Labyrinth seals are represented by **Pioneer Oilsealing** (Stand Inner 6); 'O' rings and other packings by **Angus** (Stand AA12), **Weston** (Stand Outer 6), **Beldam** (Stand D3), and by **Klinger** (C1).

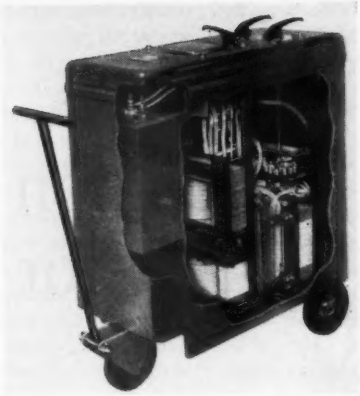
Measuring and testing instruments

The **Solus-Schall** stand (V1) displays a number of new instruments, including thickness gauge M512, magnetic wall thickness gauge 2211, ultrasonic flaw detector USIP 10, and a 180 kV industrial X-ray apparatus. **Accles & Pollock** (Stand Inner 47) are demonstrating ultrasonic and eddy current apparatus used for testing their precision tubes. **Stewarts & Lloyds** (Stand 5E) are showing the resonance bending fatigue machine that they use for tests on tubes, welded joints and welded-on fin tube. Ultrasonic flaw detectors are represented both by the **Smith Industrial Division** (Stand Inner 31) and by **Ultrasonoscope** (Stand Outer 4).



SELF-SEALING COUPLINGS —Lockheed





LWAD-TYPE WELDING UNIT—English Electric

OSCILLOGRAPH RECORDER—Southern Instruments

Among the equipment on display by **Southern Instruments** (Stand Inner 16) is a versatile multi-channel oscillograph recording system, a transistorized digital frequency and time interval meter, portable tachometers working from a photo-probe or magnetic pick-up, and the E7A f.m. pre-amplifier system for use in measuring pressure, vibration and other phenomena. The **British Arca** (Stand 6A) range of pressure, temperature and liquid level controllers are intended to complement their diaphragm operated valves. **Baldwin's** (Stand Inner 26) exhibits range over nucleonic gauges and other radiological equipment, photometric and industrial indicating instruments. Temperature instruments covered by **British Rototherm** (Stand Inner 13) include bi-metal, mercury-in-steel and vapour pressure thermometers. For the measurement of fluid flow through a pipe or duct are **Hagan's** (Stand BB14) ring balance meters. A new level detector from **Firth Cleveland** (Stand Outer 35) uses a vibrating steel probe.

Welding and metal treatment

Arc process development typified by **Rockweld** (Stand U2) includes the new 'Vertomat' for the vertical welding of plates by the CO_2 shrouded method, and the 'Circomatic' automatic seam-welding assembly for rapid shielded arc welding of girth seams on large storage tanks. **AEI** (Stand V5) are demonstrating the flexibility of their submerged arc system, in addition to new types of welding sets and heavy duty machines. For both metal arc and inert gas processes in locations requiring simple maintenance, **English Electric** (Stand W4) have introduced their LWAD range of equipment, in addition to various new pieces of ancillary equipment. **Lincoln Electric** (Stand 4U), with a wide range of machines, are showing for the first time an advanced type CO_2 gas shielded semi-automatic hand unit—the 'Sprite'. On the **Murex** stand (W2) is a model of the **Dreadnough** Submarine, on which over a million electrodes were used. Other arc welding equipment is represented by **Interlas** (Stand V9) and **Philips** (Stand T2).

Special applications of interest include a **Firth-Vickers** (Stand Inner 13) demonstration of stainless steel welding; a precision orbital method introduced by **Palmer** (Stand A11) that allows a pre-formed tube to be automatically joined to an end fitting; and a completely new range of low heat metal joining alloys from **Weldcraft** (Stand Z2). Other welding exhibitors include: **Sciaky** (Stand X5); **Kerry** (Stand EE6) for study welding; **Deloro Stellite** (Stand W3), with their new powder weld process; **Crompton Parkinson** (Stand X2); **Eutectic Welding** (Stand Y1); **Fuller** (Stand Y5); **Hirschmann** (Stand W9), with their argon arc unit; **Suffolk Iron** (Stand Y3), with their new 'Sifbronze' rods; and **Vaca-Blast** (Stand W6) for cleaning machines.

The development of remote handling methods used when examining irradiated fissile specimens is outlined

Irradiation techniques for fissile materials—5

by O. S. PLAIL, A.M.I.Mech.E., Group Leader, Irradiation Branch, Metallurgy Division, AERE, Harwell

WHEN THE IRRADIATIONS were commenced in the Windscale reactors (see Article 1, Dec. 1960) no facilities existed at AERE for the examination of the active specimens and in the first instance responsibilty for organizing the required facilities were entrusted to the same team who were carrying out the actual irradiations. Although at first glance this may seem an unnecessary extra burden, in practice it had considerable advantages as the whole of the experimental work from the inception of the experiments to the final assessment was in the hands of only one group.

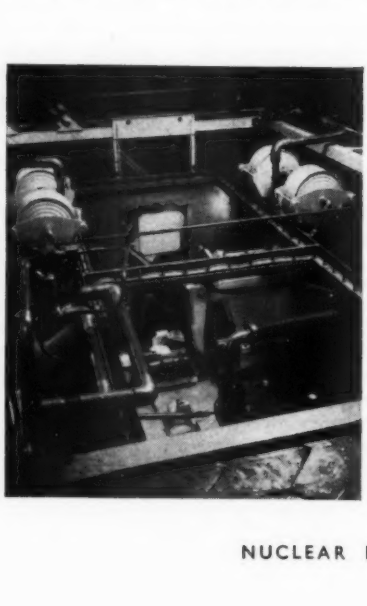
Post irradiation examinations facilities for this type of work at Harwell are now concentrated mainly in one building which is part of the Metallurgy Division although a large high activity handling building is also in existence. This has been described by Bown *et al* (*1*), and is operated by the Engineering Division; it is used extensively by Metallurgy Division for the preliminary breakdown of the irradiation assemblies to the capsule stage. These capsules containing the fissile specimens are then passed to the Metallurgy building for the detailed breakdown and extensive metallurgical examination of the specimens and it is the development of techniques for this work which will be concentrated upon in this article.

EARLY WORK

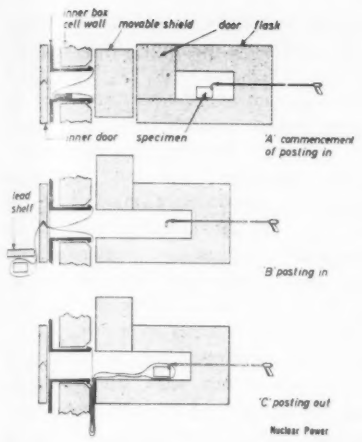
The first post irradiation facility used for these examinations consisted simply of a wood and perspex box some 4 ft square × 3 ft high mounted on a concrete plinth and surrounded by some 4 in of lead brickwork on all four sides. Little information was available in remote handling when the work started and therefore the choice of this design was rather arbitrary. Although it was realized that in the USA concrete cells using simulated wrist action manipulators were coming into use no manufacturers in the UK produced such manipulators and there were serious restrictions on the purchase of dollar material. In addition the relatively free exchange of information now in existence was not then operative. The Remote Handling section at Harwell had developed ball tong units for chemical and isotope work and these were adapted for handling the equipment and specimens inside the active cell. The design of this box and the internal arrangement of the equipment was largely governed by the area which the tong units could cover and therefore these tongs were fitted into three of the four sides at strategic positions, the box being free standing in a similar manner to the α boxes used for plutonium research. Free access was therefore available to all four sides. The top was covered with a sheet of perspex sealed rather inefficiently perhaps by means of a rubber gasket and as well as lead glass windows let into the lead wall surrounding the box, overhead mirrors were fitted to give an overall view of operations. Indicative of the unsophisticated thinking of those days was the method of sawing through cans by means of a manually operated hacksaw. This was operated from outside the box via a square section drive shaft and although it was later discarded it served its original purpose well.

These sort of devices were adopted because no experience on remote decontamination of active equipment was available and simple equipment was essential. At the time the high activity building was not available for breakdown of the rigs; therefore this first box had to be equipped for cutting the rig as well as opening the capsule, removal of the sodium, measurement of the specimen and visual examination including photography. Later a rig to measure the release of fission gas from the sample was also installed. This first box was used extensively and on the experience gained in its operation the future pattern of post irradiation examination of these small fissile samples was based.

All the early irradiations were carried out using U-235 which does not itself present a serious toxic hazard but it was soon realized that the fission products resulting from the irradiation needed very careful control and contain-



Lead shielded recanning box showing the lathe used to rotate the capsule during welding. The top perspex has been removed and the filters can be seen at the top of the box; the periscope for viewing the welding is directly over the lathe (Fig. 1)



Sequence of posting operations (Fig. 2)

ment; the original box was completely inadequate in this respect and contamination spreads were frequent. Activity escape frequently resulted from tong operations, contamination being drawn back through the ball and spreading into the laboratory. To overcome this plastic sleeves were used to cover the shaft of the tongs and these were arranged so that they could be changed from outside the box. The difficulty of restricting contamination spread coupled with the need for irradiation of α emitting material and the considerably increased programme mentioned in article 1 necessitated new boxes.

MORE ADVANCED EXAMINATION FACILITIES

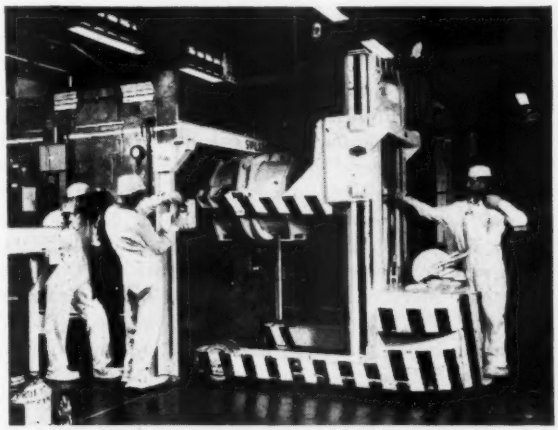
The essential post irradiation operations for work of this type can be summarized as follows:

(1) Rig dismantling
(2) Cutting of can
(3) Removal of sodium
(4) Removal of specimen
(5) Visual examination of the specimens including photography
(6) Measurement of specimen physical dimensions
(7) Determination of specimen weight and density
(8) Fission gas release from specimens
(9) Metallographic examination of specimens.

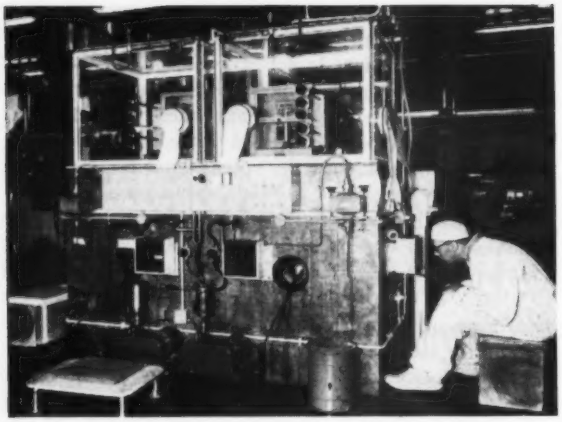
It was considered that the use of α emitting materials in the irradiation tests presented greater hazards in the post irradiation handling than those normally in existence with non-α material. Segregation of α and non-α emitters was therefore introduced. Two separate examination lines were built which became known as the $\alpha\ \beta\gamma$ and $\beta\gamma$ lines respectively. Each contained (i) a Decanning box (ii) an Examination box and (iii) a Recanning box. The Decanning boxes were capable of dismantling the rigs, gas sampling the capsules, cutting the capsule and removing the sodium and the sample. The second box was used for examination and contained a sensitive chemical balance, a specially constructed low power binocular microscope with camera attachment coupled to a vernier measuring table for dimensional checks and a diamond hardness testing machine. At the time of the Windscale experiments re-irradiation of previously irradiated samples was required and the third box therefore was needed to recan the specimens; this included sodium filling, welding of the capsule, reassembly in the rig and testing of the assembly. Fig. 1 illustrates one of these recanning boxes and shows a lathe used to rotate the sodium filled capsule during argon arc welding of the end caps (see Fig. 7c, p.94 *Nuclear Power*, Dec. 1960).

Although these two lines were in many respects identical, the problems raised by the containment of α material coupled with the high $\beta\gamma$ activity were more serious and involved separate special engineering designs in order to achieve the extremely low gas leak rates required on the boxes. Although the leak rates on the $\beta\gamma$ boxes were fairly low they could not meet the specification for α material nor were they capable of maintaining the pure gas atmosphere which is frequently essential for material such as plutonium. An increase in specimen activity was envisaged and therefore these boxes had to be capable of containing 1000 MeV c. The detailed design was undertaken by the same team of engineers under Ashburn that had designed the rigs for the Windscale irradiations.

The adherence to the lead box concept was influenced, amongst other things, by the fact that at this early stage examinations and operations envisaged could be clearly defined, thus permitting rigid design. Basically the design was similar to the earlier unit but the inner wooden box was replaced by one of welded stainless steel surrounded by a thicker lead wall (10 in). Strengthened ball tong units were used for manipulation. One of the early difficulties experienced was the considerable back scattering of γ rays due to the roof of the building and the atmosphere thus restricting the activity that could be accommodated in a box of this type to approximately 30 MeV c. Reluctantly the top viewing mirror of the early design has to be discarded and top shielding introduced. The main difference between the $\alpha\ \beta\gamma$ line and the $\beta\gamma$ line was in the gas tightness of the boxes and the method of posting in and out of samples and equipment. For the latter line posting consisted solely of offering a flask up to the posting port of the box opening the shielding door and an inner sealing flange on the box itself, pushing the article into the box and collecting it by means of a pair of tongs. In the case of the $\alpha\ \beta\gamma$ boxes a combination of the standard posting techniques for α materials and the active posting of the $\beta\gamma$ line is used. This utilizes a very long bag fitted to the posting port of the box by means of O rings. The flask is offered up to the posting port, the article pushed into the bag and allowed to rest behind the lead shielding; part of the bag is then withdrawn and welded. It is then drawn into the box and cut through the weld thus enabling posting to be performed without any leakage of contamina-



Posting operation in progress into a lead shielded box (Fig. 3)



Equipment used for weight and density measurements showing the balance sited for easy maintenance (Fig. 4)

tion or atmosphere from the box. The sequence of operations is shown in Fig. 2 and Fig. 3 illustrates a posting operation. Other aspects of these boxes differed from those of the $\beta\gamma$ lines only in so far as special seals had to be fitted to tongs and shafts that had to be taken into the box and would have interfered with the integrity of the steel inner shell. The $\beta\gamma$ boxes were supported upon a solid concrete plinth but, because it was considered that the $\alpha\ \beta\gamma$ boxes would have to be moved to a frog suit area for decontamination, plinths were not used; instead they were constructed with a built-in integral trolley to facilitate moving. The problem of adequate viewing of operation inside the boxes was to a great extent coupled with the lack of suitable lead glasses. Low density glass (2·4 g/cc) which browned on exposure to γ radiation was at first the only material available. However improvements in glass manufacturing technology have resulted in the production of denser materials up to 6·2 g/cc which are stabilized with cerium against radiation browning. These glasses have rather poor light transmission properties so that special lighting arrangements have to be adopted and it is current practice to use monochromatic sodium lighting inside the boxes.

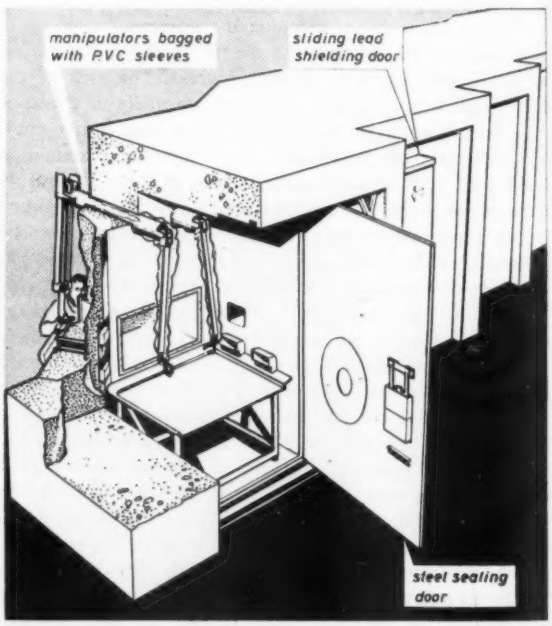
In all cases a reduced pressure in the box was maintained using a filtered extract so that under all circumstances leaks would be inwards and contamination spread would be restricted. For the $\alpha\beta\delta$ boxes atmosphere control was achieved by careful initial daily purging coupled with a continuous feed of inert gas matched to the extract flow. Details regarding the construction of these boxes have been given by Simmonds (*2*).

Wherever possible the standard equipment was used in these boxes but very frequently because of the limited range of operation of the tongs and the need for through the wall drives, special apparatus had to be designed and built. Therefore although the operations for which the boxes were built were relatively easy to perform, there was a serious limitation on the scope of the experiments possible.

The experience gained during this period can be summarized as follows:

Firstly the earlier distinction drawn between $\beta\gamma$ and $\alpha\ \beta\gamma$ proved to a large extent to be superficial as far as operation of the boxes was concerned. Most of the spreads of contamination that occurred could be traced to the $\beta\delta$ boxes and mainly to posting operations. Secondly, it was realized just how difficult and time consuming decontamination could be. This is due in part to the internal arrangement of fixed equipment and the positioning of the various tong attachments which provide convenient places for contamination to collect. Thirdly, the maintenance problems with the fixed equipment and fixed lead walls are considerable; this was particularly marked in the case of the maintenance of the sensitive balance used for the density determinations. Any major maintenance job involved not only the decontamination work first but frequently complete removal of one or more of the lead walls with possible removal of the inner steel box.

These boxes had been accommodated in temporary buildings and therefore when they were moved to the permanent Metallurgy active handling building, the opportunity was taken to make radical changes in both design and method of working. These changes which have taken a long time to complete are as follows. Firstly, all boxes have been changed from $\beta\gamma$ to $\alpha\ \beta\gamma$ working. This resulted in a very much cleaner operation and has not significantly increased operational troubles. Secondly there has been a gradual change from the principle of fixed equipment in the boxes to that of having everything possibly removable and of such a size that it can be posted in and out of the box for maintenance purposes. This frequently means that the equipment has to be in sub units but this has considerably eased maintenance problems. For instance metallographic polishing is performed on a specially developed machine which will dismantle into several components each of which will pass through the posting port. A slightly different aspect of design for ease of maintenance is shown in the equipment used for weight and density determinations (see Fig. 4). It will be seen that although the whole of the apparatus is contained, the only portion behind lead shielding being that used for the active



Basic design of concrete cells (Fig. 5)

specimen. Thus the balance which before was hidden behind lead walls can now be maintained by means of gloves situated inside the upper box. The third change made resulted from the other two and concerned the actual box operation. In the earlier work largely because of the difficulties in handling the equipment all aspects of the specimen examination had been undertaken by scientific staff but this was altered and the operational work was transferred to highly trained non-professional staff for many of the more routine examinations. For instance the removal of the sodium, dimensional checks, posting of all specimens into and out of the cells and many other functions are now performed by these staff. This system only works if the scientific staff give adequate and constant supervision and by and large this scheme has worked well and enables greater use to be made of experimental and scientific staff. Even the weighing and density determination where very accurate weighing is required are carried out in this manner. Finally, the recanning process although possible was very time consuming and was therefore abandoned but the boxes were adapted for other uses. For instance the lathe previously used to rotate the cans for welding was modified and used for machining tensile test specimens.

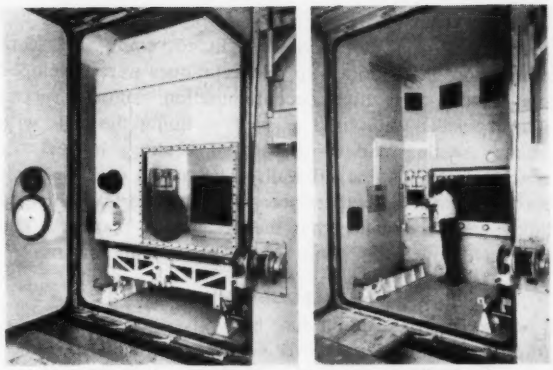
One aspect of the move to the permanent building was the fact that as well as $\beta\gamma$ decontamination a technique was perfected using a plastic hood fitted with gloves which when fixed to an α contaminated box permitted decontamination without transferring to a frog suit area as is normally done in such cases. This was a most important exercise as it modified our subsequent thinking to a large degree.

NEW CELLS

The culmination of these changes has led to the installation of new concrete cells for $\alpha\beta\gamma$ work utilizing master slave manipulators. The lead shielded boxes have given extremely reliable service but the maintenance and operational difficulties led to the need for a much more flexible facility in order to cope with the considerably increased flow of work resulting from a widening of interest in irradiation effects. In addition, special post irradiation experiments on a one off basis are becoming more important and it would be uneconomic to build special facilities. Up to the time of the design no serious attempt had been made to combine both α and $\beta\gamma$ activity work in a concrete cell. The requirements for these new cells were therefore:

(1) Complete flexibility of operation
(2) Easy access in order to change equipment readily
(3) Both $\beta\gamma$ and α $\beta\gamma$ working
(4) Atmospheric control for special experiments.
(5) Decontamination to be as easy as possible without the use of frog suit area
(6) Design so that standard equipment could be used almost exclusively
(7) Ability to set up and test equipment on a trolley so that installation time in the cell is reduced to a minimum
(8) The cost to be kept to a minimum

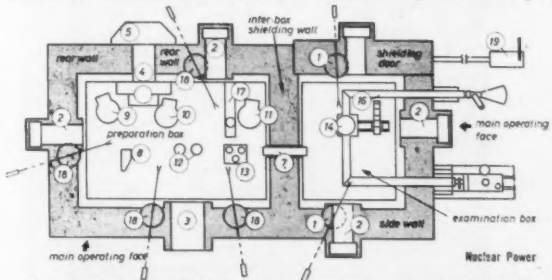
The basic design for these new cells is shown in Fig. 5. They consist of units joined together and constructed in such a fashion that the whole cell has a very low leak rate. The back of the cell is sealed by a large steel door which seals onto a rubber flange thus giving a considerable degree of leak tightness. Behind this is a sliding lead door to give biological shielding. Both are the full height of the cell and open to accept a α tight box, which is constructed so



(Left) View of concrete rear of concrete cell showing α box in position. (Right) View of concrete cell rear sealing door and lead glass window, manipulators are not installed; the posting port is being lined (Figs. 6 and 7)

that the manipulators can enter special snouts to which are attached plastic sleeves similar to the plastic sleeves used on the tongs in the lead boxes. These sleeves provide α tight sealing round the manipulator. The posting technique is similar to that adopted for the lead boxes. The choice of this rather large α box was made mainly on the basis of ease of operation of the manipulators; a smaller box with the manipulator entering the top would have restricted the volume of working space available. This inner box is provided with detachable panels so that after decontamination has been carried out to a large degree the maintenance and final decontamination can be completed by hand using the plastic hood described above. It is normal to use the $\beta\gamma$ activity as a tracer for the alpha contamination.

The method of operation for these boxes is as follows: An experiment is first built up in one of the movable α boxes or if this is not required on a trolley, the operating techniques established preferably using a mock-up cell. The box is then installed in the concrete cell, the rear door closed and the post irradiation examination or experiment performed. After in cell decontamination the rear door is opened and the α box removed for dismantling and final decontamination. Figs. 6 and 7 show the rear of one cell with and without an α box. It is obvious that this scheme can only work if adequate decontamination can be performed on the box and equipment inside the cell. To establish feasible techniques and to test out the design, a wood and hardboard mock-up was constructed and a series of experiments performed on this model. Apart from the remote manipulation aspect mock-up decontamination trials were performed using fluorescent materials to simulate activity. Tests using the manipu-



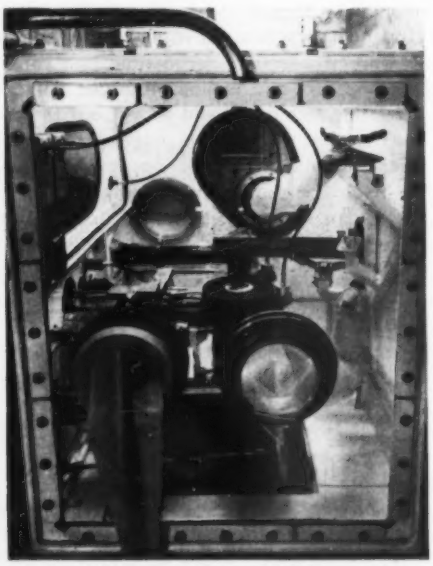
1 ½ in tong unit; 2 6 in x 6 in — 8 in x 8 in window unit; 3 10 in x 6 in window unit; 4 posting part; 5 outer posting door; 6 inner posting door; 7 transfer trolley; 8 specimen mounting unit; 9 micro grinding unit; 10 micro polishing unit; 11 micro attack polishing unit; 12 ultrasonic wash unit; 13 acid bath; 14 microscope; 15 illumination transfer optic; 16 vision transfer optic; 17 drain; 18 ½ in x ½ in tong unit; 19 hydraulic ram.

lators to clean down the cell were performed and it was found that using ultra violet light to 'count' the 'contamination' in the mock-up cell techniques were developed that gave a very high decontamination factor. Special shaped swabs were used as well as lining the cells with plastic sheeting and using sprayed coatings to seal the contamination of the cell wall. The results of these trials combined with the experience gained on the lead shielded boxes gave confidence that the design was feasible. The cells have now been completed and are coming into use.

METALLOGRAPHY

So far no description has been given of the metallographic facilities but this is because this work is rather specialized. The first metallographic examination of irradiated samples was carried out by Sykes *et al* (*3*) at AERE on a very small laboratory built lead shielded box. The first unit continued in use for lightly irradiated material until comparatively recently. It consisted essentially of a 4 in lead wall surrounding an area in which were located standard metallurgical polishing machines, mounting press and metallurgical microscope. As can be expected this unit suffered from the same drawbacks of the first handling box and considerable contamination spread was experienced. Therefore a new line was constructed on the basis of the experience gained and this consisted of a series of preparation boxes inter-connected and terminating in a microscope box. This microscope was to all intents a standard article but because no suitable angled transport optic was then available it was adapted for direct viewing so that by introducing a television camera in the viewing train the image could be displayed upon a television screen using a closed circuit.

This system reflected not only the uncertainty surrounding remote handling but also the lack of suitable equipment whereby remote viewing could be obtained whilst preventing the operator from danger due to radiation. It, too, suffered from the two major worries of these earlier remote handling lines i.e. difficult maintenance and contamination spread. One of the outstanding parts of the development undertaken on this line was that of remotely controlling the microscope. Other drawbacks were the low activity that could be accommodated in the line and the few specimens that could be dealt with. However, in spite of these difficulties it continued in operation for several years but was eventually replaced by a more sophisticated unit. The design and construction of this new line was influenced not only by earlier remote metallographic experiments but also by the large amount of general operating experience.



Internal view of microscope box showing controls, handling tongs and glove positions in perspex panel for maintenance, the sliding lead door has been moved away (Fig. 9)

Internal view of polishing box showing polishing machine in position (Fig. 10)

The basic layout is illustrated in Fig. 8. It was designed for handling $\alpha\ \beta\gamma$ active samples but at the same time, in order to make maintenance easy, the open area principle was used. The unit consists of two boxes joined together but separated by a lead shielding wall through which is fitted a small posting port. The larger of these two boxes is maintained as a dirty or polishing box in which are situated specially constructed polishing machines which dismantle and post out for maintenance and in this side no fixed equipment is installed. The other and smaller box houses a similar metallurgical microscope to that of the earlier unit but being segregated from the polishing side, and as cleaned specimens only are passed into it, it very rarely becomes contaminated. Thus the maintenance of the microscope is relatively easy and access is given by a sliding lead door maintenance being carried out via glove ports in a side panel of perspex. Viewing is by a direct transport optic or by closed circuit television if a group of people are present. Experience to date has been most encouraging, the main disadvantage found so far has been that the polishing side can deal with many more samples that can be examined. Figs. 9 and 10 show general views of the facility.

Acknowledgment

Acknowledgment must be made to Mr. I. Barwood, AERE, Mr. B. Sharpe now of CEGB and Mr. H. Venables, AERE for their considerable contributions to the developments discussed in this paper.

References

1. Bown, J. E., Antwiss, J. W., Ritchie, A. B., Cassie, G. E. A/Conf. 15/P/1459. United Kingdom. 'The High Activity Handling Building at AERE, Harwell.'
2. Simmonds, G. E., AERE Glove Box Symposium Paper No. GBS/38. Lead Shielded $\alpha\ \beta\ \delta$ Cells for 1000 MeV curies. A review of Engineering Design.
3. Sykes, E. C., Haddrell, V. J., Elson, A. W., AERE Glove Box Symposium Paper No. GBS/49. Metallographic Examination of Irradiated Fissile Materials.

Manipulator development in the USA

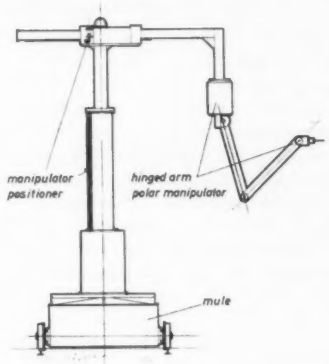
special purpose mobile units

A new chemistry cave complex, referred to by W. C. Mohr and C. H. Youngquist at a recent conference (see *Nuclear Power*, February, page 74), is being designed at the ANL. It consists of a series of 14 ft by 16 ft working cells connected by a shielded corridor. A second floor level served by an elevator will consist of essentially the same cell arrangement. To move the containment boxes, pots, and other materials, a rail system has been planned and incorporated as part of the cave. A low battery-powered, radio controlled mule will be used that runs in straight lines with remotely operated turntables at rail intersections. Maximum speed is 1 ft/s and the maximum load-carrying capacity is 2½ tons.

In addition to the primary manipulators, ANL model 8 master slaves, a mobile manipulator has been designed to serve a series of cells. This consists of a commercially available hinged arm polar unit and a manipulator positioner, the two mounted on the radio controlled mule. Power and controls will not be part of the mule, but will be brought in to the mobile manipulator by a plug that will be coupled after the mobile manipulator is positioned in the working cell.

The positioner consists of a square tube that can move vertically or rotate within a fixed cylindrical guide tube. The latter is braced by encasing it with a larger diameter tube at the lower end. The telescoping square tube supports a radially travelling horizontal boom which in turn carries the manipulator. The whole assembly is mounted on a heavy base plate that can be bolted to either the mule or at some predetermined location on the floor. Mounted on the mule, the polar manipulator can be positioned to cover the volume contained in a cylinder 18 ft dia. extending from floor level to a height of 11 ft 2 in.

Carrying capacity of the manipulator, with its arm fully extended in a horizontal position is 25 lb; the maximum size of objects to be carried is 4 in². The manipulator positioner will lift up to 100 lb suspended by means of a hook below the shoulder pivot point of the manipulator. The horizontal travelling boom is a square tube supported between rollers with a spur gear rack fixed to the underside.



The ANL mobile manipulator

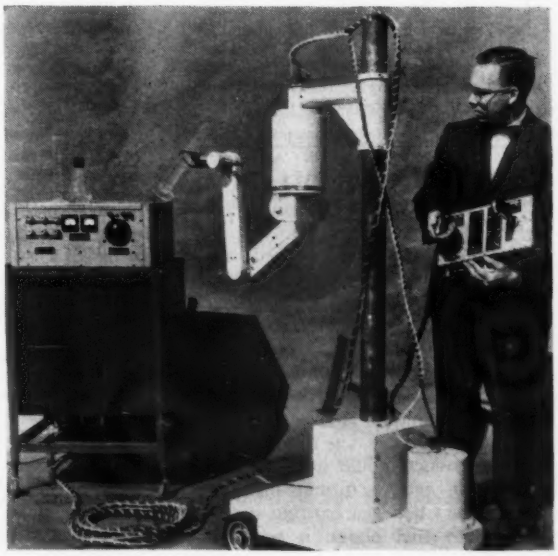
A smaller mobile unit in use at the Esso Research Centre for handling high energy solid rocket propellant ingredients, described by J. A. Brown and W. A. Koelsch, also works under remote control through a 60 ft trailing cable linked to a simple transistor power unit. Control is effected by varying the voltage and polarity from a remotely located control box.

The dolly base has a combination driving and steering unit coupled to the single rear wheel. It runs forward and reverse at variable speed. with a steering wheel that turns through 360°. A steel pillar is fixed to the bed of the dolly over its centre of gravity, and the arm is suspended from a short beam which can be clamped at any height on the pillar. The manipulator arm, a commercially available unit supplied by Koelsch, is powered by 24V d.c. motors located inside the body shell. Power is sent down the arm by sprocket chains, and is carried past the shoulder, elbow, and wrist joints by concentric shafts through the joints.

The control box mounts two joysticks; one controls all motions of the hand and arm; the other controls the dolly. There is a pair of micro-switches for each motion of the arm. Four pairs are clustered around the base of the joystick and respond respectively to four independent motions of the stick; two more pairs are located behind buttons on the hand grip. This combination makes for a rather complex system of mounting yokes, but it results in an entirely natural control.

Future modifications include a dolly with caterpillar treads that will simplify the problem of gearing, since no swivelling need be provided. A ball-screw elevating mechanism for the arm will give rectilinear vertical lift, a motion that the present machine can do only by the combination of two simple motions, such as elbow-plus-shoulder, or shoulder-plus-dolly.

★ 280



This versatile manipulator, made by Koelsch for the Esso Research Centre, can reach from the floor to the ceiling, move around inside the cell while working, and enter and leave under its own power. It is used for handling high energy solid rocket propellant ingredients

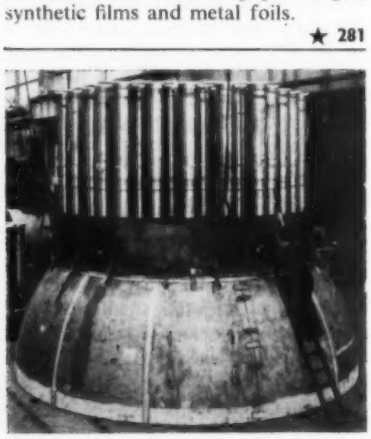
Radioisotopes in the USSR

new thickness meter

A beta thickness gauge for measuring layers of printing ink on blocks, or layers of galvanized coating on metals, has successfully passed its development period and is in the initial production stage. The Soviet Printing Industry Research Institute, responsible for the development, have also completed a similar meter for use on areas under 1cm diameter. It is to be applied to measuring layers on small uneven surfaces, e.g., nickel and chrome on type faces, copper on rotary stereos, and layers of printing ink on metals.

Another beta-gauge developed recently may be used in the control of printing ink on printing press rollers, for the measurement of paper weight, synthetic films and metal foils.

★ 281



WINDSCALE'S HERO PROGRESSES The top dome of the Hero reactor vessel is ready for despatch. Built in ten pieces by Ashmore, Benson, Pease, this 50 ton vessel with ½ in thick SS walls has an internal diameter of 21 ft and an overall length of 52 ft. The dome is fitted with 60 standpipes, the top surfaces of which have to be parallel to within 0·005 in. On erection these surfaces must be positioned at a height of 49 ft 2 in above the vessel supports with an accuracy of ± ⅛ in

★ 282

New fuel elements

glass fibres used

Experiments are being carried out at the Rensselaer Polytechnic Institute to develop a new concept of fuel element in which fissionable materials are contained within ordinary glass fibres.

Working at first with fibres of about 1/10,000in dia., manufactured by established techniques, and later by increasing the diameter, it was found that the fission products could not escape and that their energy turned into heat. Sandwiched between existing types of aluminium fuel plates, it is claimed that glass fibres could be used to a temperature about twice that of existing plates, and could readily replace existing designs.

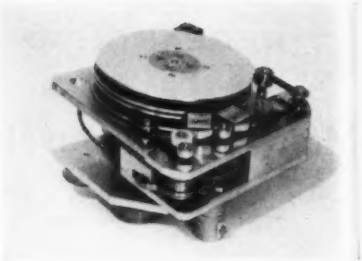
Because the fibres act, in a way, as their own filter for radioactive contaminants, it was found much cheaper to reprocess this new form of fuel element after first use. By incorporating plutonium into the glass fibres, the Institute found that handling was possible without the normal radiological and toxicological hazards.

★ 283

Miniature tape recorder

low power consumption

Primarily designed for satellite and missile application and capable of operating on 1/20th of the power previously considered practical, is a new miniature magnetic tape recorder/reproducer developed by Consolidated Electrodynamics. With a power consumption rated at considerably less than 1W, the instrument has an estimated life of at least 4000h, operates at a reproduce-to-record speed ratio of 18:1 and weighs less than 6 lb.



The new miniature tape recorder/reproducer designed by CEC

The unit will record for approximately 2½h at 1 in/s and play-back in about 8 min. The present system has a reproduce frequency range of 1kc to 25kc. Significant design features include a new type d.c. motor for primary drive which uses rolling rather than sliding brushes; an electronic speed control system which controls the motor speed $>\frac{1}{4}\%$, with a consumption of <40mW and the use of Mylar belts.

★ 284

IN BRIEF

FUEL PROCESSING US Patent 2,951,740 deals with an improved 'Purex' process of separating uranium, plutonium and fission products from nitric acid solutions of neutron-irradiated uranium.

★ 285

CONTROL RODS US Patent 2,952,600 relates to a control element that comprises a multiplicity of sections arranged in end-to-end relationship, each of the sections having a markedly different neutron-reactive characteristic.

★ 286

ACCELERATOR TEMPERATURE CONTROL US Patent 2,956,201 covers a method for controlling the temperature of a particle accelerator by providing two individual heating applications, the first being employed only when the accelerator is de-energized.

★ 287

MICRO-TENSILE TESTING Tube Investments have developed a micro-tensile testing machine that measures, by optical and mechanical means, extensions in specimens having cross-sectional areas down to 2×10^{-6} in^2.

★ 288

NEUTRON FLUX CALIBRATION The value of the standard thermal neutron flux maintained by the National Bureau of Standards has been changed as the result of a recent gold foil recalibration. The new value, 4203 n/cm^{2}s, is a weighted average of the gold determination and a previous value based on the cross-section of boron.

★ 289

WATER BOILER REACTOR US Patent 2,961,391 from Los Alamos relates to an aqueous solution reactor. Using a cylindrical reactor vessel, a critical region is provided that has a large and constant interface with a supernatant vapour region. A hollow sleeve coolant member suspended from the cover assembly is in co-axial relationship with the reactor vessel.

★ 290

TRAWSFYNYDD GRAPHITE LIFT A Matterson radial crane is to be used at Trawsfynydd for handling the graphite moderator blocks. With a radius of 21 ft 6 in, the whole assembly has to be taken, piece by piece, through a 50 ft pipe, and assembled inside the reactor.

★ 291

HIGH TEMPERATURE GLASS Part of a Boeing study of high temperature gases, head-on collision of two shock waves, 80 times faster than sound, has been achieved in a hydromagnetic tube 12 ft long × 6 in dia, made from Corning borosilicate glass.

★ 292

DATA PROCESSING The original IBM709 at the UKAEA's establishment at Aldermaston has been replaced by a 7090. This is a fully transistorized machine capable of operating from four to six times faster than the earlier model. It has a magnetic storage for 32,000 computer words of 36 bits each.

★ 293

ACCELERATOR POWER SUPPLY A GEC 115-ton reactor choke will supply both a.c. and d.c. power to the 16 separate magnets forming the heart of the USAEC's 3GeV synchroton, under construction for the Universities of Princeton and Pennsylvania.

★ 294

★ *For further information on any item, circle the appropriate number on the reply card facing page* 106.

New Product Survey

EQUIPMENT · INSTRUMENTS · MATERIALS

REFRACTORY COATINGS

high temperature protection

A new type of refractory protective coating has been introduced by Corrosion Ltd, based on zircon, that has applications up to 2000°C. One suggested use is on the waste gas outlet sides away from the reactor, as a protective coating against corrosive effects by waste gases at elevated temperatures. It can also be used on all steam producing plant where temperatures up to 2100°C are experienced.

Furnascote, which can be applied by trowelling, brushing or spraying is available in three ranges, depending on the particular function. Mortar—for bonding, patching and plugging, can be used up to 1650°C; Higlaze 2230—that can be used as a finishing coat, is suitable from 1200° to 1650°C; the universal Nonvit—with smooth matt white finish, is used in the range 10° to 1910°C. Higlaze used in conjunction with the Mortar increases temperature resistance to 2000°C and also acid resistance.

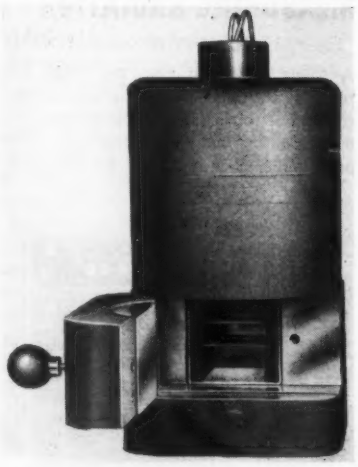
★ 208

RADIATION COUNTING

four-in-one application

Hamner's new model A-500 universal counting shield provides in one unit four distinct types of radiation counting applications: scintillation well, scintillation planchet, flow proportional, and Geiger-Müller counting.

Guaranteed completely free of cobalt-60 activity, the grade of iron selected is claimed to yield maximum mechanical stability and, concurrently, low shield material background activity. Since the shield screens the enclosure with 2½ in of iron on all sides, including the bottom, cosmic ray back scatter entering the chamber from below is reduced. This amount of iron gives an attenuation equivalent to about 1·85 in of lead. The enclosure is lined with ⅛ in of aluminium to reduce back counting errors to a minimum.



Assembled in four main sections, the new Hamner shield is supplied with carrying rod and eye bolts to facilitate handling

★ 209

LEVEL INDICATOR

high and low control

Following up the introduction of the 'Levolog' continous level indicator, another instrument has been developed by Thomas Industrial that incorporates high and low level control as well as continuous indication.

The 'Levelrator' uses one electrode only for both functions; alarm points can be set to operate over the full length of the electrode to suit particular applications. The electrode system can be of the rigid variety for a small vessel and of the flexible type when the depth exceeds 6 ft, limiting length of available electrodes being 60 ft. The high or low level control points are completely independent of the indicating instrument, and the relays are operated by a specially designed electronic circuit.

The control unit consists of a stabilized power supply, alarm relay circuits and built-in calibrating instruments, and it can be situated up to 150 ft from the electrode head unit.

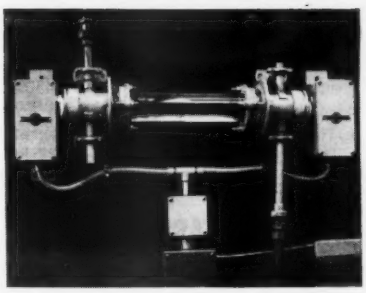
★ 210

WATER MONITORING

turbidity meter

In circumstances where normal filtration equipment is unable to deal with the high percentage of suspended matter that may exist in mains water, a system has been devised by Radiovisor that prevents the water entering the storage tank.

Consisting basically of a photo-electric turbidity meter, the monitoring equipment comprises a glass sampling chamber designed for a working pressure of 50 lbf/in². At one end is fitted a projector that directs its light on to a photo-electric cell receiver at the other end. The measuring amplifier is connected to a 6 in scale indicating meter, calibrated in ten arbitrary units, to provide a continuous reading of variation in turbidity.



The Radiovisor photo-electric turbidity meter is used for either monitoring or checking mains water clarity. A fully automatic system is envisaged that uses motorized and solenoid valves

By means of remote warning panels fitted with alarm bells and indicator lights, immediate action can be taken when excess of turbidity occurs. Depression of a muting switch cancels the bell but maintains a red warning light which remains energized until normal water conditions are restored.

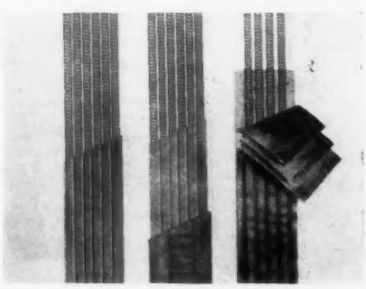
★ 211

RIG HEATING

flat foil elements

Used at the UKAEA, Winfrith, on organic loops, the Hotfoil flat-element heating tape recently introduced by M.E.I. represents a new departure in electric heating. Providing an effective method of raising temperatures or compensating for heat losses from pipes and tanks, the tape uses metal foil elements insulated with high temperature plastic material and woven glass. By this method, it is claimed that loadings are over twice those obtained with round-wire conductors.

Three Hotfoil tapes are available. Type A—for heating to 110°C—1 in wide and 0·012 in thick, is double plastic insulated and yields loadings up to 3 W/in². It is suitable for confined applications and can be wound around pipes and containers of any radius greater than ¼ in. Type E is similar to the above but has an additional woven-glass protective covering. Both



The new Hotfoil flat-element heating tape is available in three forms—type G being suitable up to 450°C

tapes are available in standard lengths from 12 to 100 ft in a variety of loadings. Type G—insulated with triple woven glass layers—is suitable for heating to 450°C. Available in standard lengths from 6 to 70 ft, it has a low thermal mass and provides loadings up to 15 W/in².

★ 212

LINEAR MEASUREMENT

adjustable transducers

Accurate linear measurement is possible with a system developed by Reilly Engineering that employs an adjustable transducer head and an a.c. indicator bridge.

Used as a hand-set instrument, adjustment of five decade switches, with a range from ten steps of 1 in to ten steps of 0·0001 in each, in a checking operation taking about 10 seconds, the accuracy achieved is ±0·00002 in. For inspection purposes, the decade switches adjust themselves automatically as the transducer head is moved on its shaft to each new position.

The transducers can be supplied in models ranging from a unit for measurements up to 500 ft to one capable of measuring 0·0000001 in.

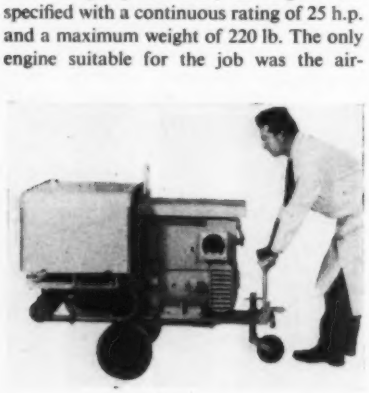
★ 213

ELECTRIC ARC WELDING

portable unit

Max Arc have introduced a completely portable and self contained engine-driven welding unit, the 'Port-el-Arc', that weighs 670 lb without the undercarriage. The generator and engine can be mounted on skids or on a trailer, the latter has a jockey wheel that enables the operator to manoeuvre the complete unit in the most confined space. The engine and generator may be completely separated by simply removing six accessible nuts. A spigotted flange and three-point flexible coupling ensure perfect alignment and positive drive when re-assembled.

In designing the unit, an engine was specified with a continuous rating of 25 h.p. and a maximum weight of 220 lb. The only engine suitable for the job was the air-cooled Volkswagen petrol engine. By means of a welding controller mounted on the generator frame, the dual control system enables the operator to adjust the current to suit each individual class of welding job. There are 10 current settings and a portable and independent controller provides stepless regulation on each setting. In addition to the facility for infinite adjustment through the range 20 to 300 A, the operator may also choose any striking voltage from 65 to 90 V.



The new Max Arc portable engine-driven welding unit with Volkswagen engine and generator

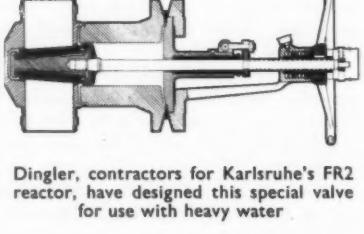
★ 214

VALVES FOR HEAVY WATER

double-disk wedge-type

Completely tight sealing is claimed by Dingler for its new double-disk wedge-type valve designed for use with heavy water. To avoid deposits of suspended matter, and to limit the volume of heavy water to the least possible extent, the hollow space in the valve's interior has been kept very small.

The stuffing box is equipped with a sealing-off circuit, in which there will be either a sealing agent injected under high pressure, or a means of drawing-off the active heavy water that has leaked through. Between the cover and casing is a weld seal that is not subjected to pressure. Heavy water leakage to the outside is therefore impossible. Materials of construction can be selected to satisfy various operational conditions.



Dingler, contractors for Karlsruhe's FR2 reactor, have designed this special valve for use with heavy water

★ 215

RADIATION MONITORING

hot spot probe

Designed for the measurement of hot spots of beta and gamma radiation over the range 0·05 to 100 r/h, the Avo hot spot monitor 1657A is intended for local radioactive material that may have been deposited during processing.

The ionization chamber has a volume of 160 cc and is made in the form of an aluminium cage supporting a 'Melinex' foil 0·00025 in thick. The chamber can be mounted on any combination of three interlocking extension rods and a flexible connector, thus permitting its use at a distance of up to 13 ft from the operator.

By means of a small strontium-90 source and two switches on the indicator unit, the operator can carry out operational checks even when the chamber is in an intense field.

The Avo hot spot monitor can be used at a distance of up to 13 ft from the operator, if required

★ 216

NEUTRON COUNTER

scintillation type

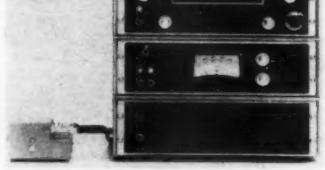
Three ranges — 0-50, 0-500 and 0-5000 n/cm²s — are provided in the new Eberline model FN-1A fast neutron counter that features an insensitivity to gamma radiation to 1 r/h. Using a 2 in dia × ¼ in thick ZnS plastic crystal, the instrument is splash proof, shock resistant and capable of operating up to +54°C. High voltage supply, amplifier-trigger and meter accessories are supplied on transistorized plug-in cards.

★ 217

MEASURING RADIATION

four chassis assembly

A single integrated unit, the Logic 801, recently introduced by Nuclear-Chicago, consists of four chassis, each of which can be purchased as a separate unit. The preamplifier chassis is used for the ampli-



Nuclear-Chicago's radiation measurement unit serves four functions: preamplifier, high voltage supply, scaler, and timer

fication of pulses from the Geiger, scintillation or proportional detectors, provides gains of 1 or 20 and accepts positive or negative input pulses; another chassis supplies a super-stable polarizing potential for all types of radiation detectors.

The scaler chassis which indicates as many as 999,999 counts and has a resolution of 1 μs, will accept positive or negative pulses from a detector or amplifier. The timer chassis presents time in increments as small as $^1/_{1000}$, and has a maximum drift of 1 ppm/week. Decimal point selection is automatically set by the range switch and readout can be supplied to a digital recorder.

Scaler and timer chassis provide continuous elapsed time and accumulated count data through in-line numerical readout.

★ 218

MULTI-POINT RECORDER

one-strip chart

For research and process applications where the numbers of records being monitored change frequently, Honeywell have designed a new version of their multi-point electronic strip chart recorder. The 'Universal' recorder now enables alternatives of 2, 3, 4, 6, 8, 10, 12, 16, 20 or 24 points to be measured and recorded on one instrument.

Variation is obtained by replacing the print wheel-cum-indicator dial and the shorting plug unit on a special input terminal board inside the instrument. The range may also be changed by slipping in new range resistor cards; different types of measuring unit can be compensated for by slipping in a new input terminal board.

★ 219

SAMPLE CHANGER

horizontal drive

Tracerlab's new SC-100 'Multi-Matic' accommodates 50 samples—alpha, beta, or gamma emitters—of any size up to two inches. A horizontal drive is used that allows instant sample accessibility and quick loading or removal without disturbing other samples or the sample being counted.

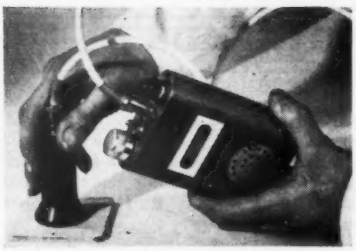
Recycling of a single sample, by-passing of empty sample positions, recycling to the starting position, or programming samples for any number of cycles, are all automatic and operated through a single knob control.

★ 220

METAL COATINGS

audio thickness meter

Specially developed to rapidly check non-magnetic sprayed metal coatings on magnetic base materials, the new audio



Designed specifically for sprayed zinc and aluminium coatings, the new Metallisation thickness gauge is fully transistorized and is unaffected by magnetic fields or stray magnetism

thickness meter, developed by Metallisation, gives an audible indication when the thickness and quality of the sprayed coating falls below that of a known standard. It uses the passage of eddy currents in the sprayed coating, being sensitive to changes in resistance of the coating metal. While the exploring head is designed for flat surfaces, adaptors are being designed to enable the unit to measure curved surfaces and tubes.

For setting the probe, a standard test plate, with the composition and sprayed metal coating of the composition and minimum thickness required, is selected. For most commonly sprayed metals the instrument will cover the range of 0·002 in to 0·012 in coating thickness. The meter is unaffected by adjacent steelwork and it can be used inside tanks, or channels, without further adjustment.

★ 221

IN BRIEF

• **Waterproof joint filler.** Intended for use in expansion joints in water-retaining structures where ordinary joint fillers are unsuitable, Hydrocor, manufactured by Expandite, takes the form of strips up to 18 in wide and in lengths up to 5 ft. It consists of clean granulated cork particles bound together by an insoluble synthetic resin.

★ 222

• **Radiation shielding.** Chance Pilkington have designed for use with a cobalt-60 teletherapy unit, a special window, 34 in thick, consisting of three blocks, each of a different size to break up any X-radiation that may seep along the edges. With a density of 2·67g/cm³, the glass used has a slightly yellow appearance and will resist darkening to a greater extent than normal unstabilized glass.

★ 223

• **Speedier data processing.** By use of a thin magnetic film memory, Remington-Rand's Univac 1107 computer can attain internal referencing rates at speeds measured in mμs. Taking the place of the ferrite core, the metal film, several millionths of an inch thick, is of circular shape deposited on a thin glass plate.

★ 224

• **Electromagnetic flowmeter.** A magnetic flow metering system has been introduced by Fischer & Porter that handles liquids and slurries with a conductivity as low as 0·1 micromhos/cm.

★ 225

• **Tangential fan.** Using the tangential flow principle of air circulation, the new Firth Cleveland fan manufactured in the UK by Solartron, can be incorporated in heating, cooling and drying devices. Compared with other fans in the low and medium power range, at a given frontal area and at a given speed of rotation, it will give a higher aerodynamic power output.

★ 226

• **Geiger counter.** Of approved Harwell design, Photoelectronics 'Amatron' portable radiation monitor can be operated by either battery or mains supply. Visual and audible means are provided for indicating contamination by use of a large neon and a 2½ in loudspeaker. 6 ft of co-axial cable separates the G.M. probe from the main unit.

★ 227

• **Battery operated amplifier.** Intertechnique's ASC101 logarithmic d.c. amplifier covers six decades with a drift lower than $^1/_{10}$ decade from −40 to +70°C. Connexion with a pressurized ionization chamber of 100kg/cm², allows the measurement of radiation doses from 1mr/h to 1000r/h.

★ 228

• **Drilling concrete.** Coventry Compressors are now equipped to supply hollow tubular steel drills, diamond tipped, that can make holes up to 12 in dia. through 10 ft of reinforced concrete. The drills are specially suited to work where excessive noise, dust and vibration are to be avoided.

★ 229

• **Uranium carbide.** Spheroidal or granular uranium monocarbide of 200 mesh to $\frac{1}{8}$ in particle size is available from Vitro. With a density of 13·54–13·63g/cm³, the small spheres, in the 100 to 400 micron size, can be pressed and sintered into desired shapes by powder metallurgy techniques.

★ 230

• **Chemically resistant floors.** Stronger than concrete, with a resin content to provide protection against many acids, alkalis and solvents, is the claim made by Corrosion Technical Services for its 'PXY' epoxy resin monolithic flooring.

★ 231

• **Particle detector.** Composed of single crystal high purity P-type silicon with a shallow N-type surface diffused layer, Semi-Elements' new detector will detect alpha particles, proton and heavier particles. Resolution is below 4%, signal-to-noise ratio is catalogued at 15:1.

★ 232

★ *For further information on any item, circle the appropriate number on the reply card facing page 106*

STUDENTS' NOTEBOOK

GROUNDWORK—Reactors

What is criticality and why are sub-critical assemblies useful?

Fission in natural uranium yields approximately 2·5 neutrons of high energy; these need to be slowed down before they produce further fissions and in this slowing down or moderating process some neutrons are lost by absorption. The number of neutrons absorbed is dependent on the composition and arrangement of the system. The ratio of the average number of neutrons produced to the average number of corresponding neutrons absorbed is known as the infinite multiplication factor, k_{oo} when an infinite system is considered. If the value of k_{oo} is unity then the chain reaction is maintained; if $k_{oo} > 1$ the number of neutrons will increase indefinitely. This however only deals with an infinite unpoisoned reactor. When the effects of leakage, xenon poisoning and temperature are taken into account the infinite multiplication factor is modified and the effective multiplication factor, k_{eff}, of a finite poisoned system can be considered. If k_{eff} is unity then we are dealing with a critical system. A system with $k_{eff} < 1$ is subcritical, $k_{eff} > 1$ supercritical. A subcritical assembly can thus be defined as an arrangement of fissile material and moderator such that a chain reaction cannot be maintained.

Some interesting figures can be given of the effect of various moderating materials on critical mass, that is the minimum mass of fissile material able to sustain a chain reaction. A bare sphere of 93% enriched U-235 has a critical mass of ~52kg. If, however, this is surrounded by a thick shell of natural uranium, the critical mass of enriched uranium is reduced to ~17kg because of neutrons being reflected by the natural uranium blanket. A thick water reflector reduces the critical mass to ~35kg. An important consideration of criticality is, of course, geometry and the disposition of the fissile material in the moderator. For instance, a homogeneous mixture of U-235 and water surrounded by a water reflector has a critical mass of ~800g. This is because of the effectiveness of water as a moderator and the large fission cross-section of U-235 at low energies.

Subcritical assemblies have an important design function. They can be used to determine the overall neutron absorbing and reflecting characteristics of reactor core structures. An assembly is built usually on a one-third or one-fourth scale using the same composition and structure as the proposed reactor. An external source of neutrons is used; this can be a radioactive source, positive ion accelerator producing neutrons when a target is bombarded, or neutrons from a thermal reactor. In this way steady state conditions can be attained and the flux measured in at various points. The fluxes produced at any distance will be of the same order of magnitude as the dimensions of the experiment. Such an experiment is usually called an exponential experiment as the neutron flux falls off with distance in an exponential manner.

Subcritical assemblies are also useful teaching and experimental aids. The infinite multiplication factor defined above, is a quantity which is a function only of the nuclear properties and physical dimensions of a lattice. It is independent of the size of the core and the flux level. Thus these assemblies are used for basic research into the nuclear parameters of various lattices and the testing of the validity of the theories which are used for the prediction of k_{eff}. The infinite multiplication factor is affected by changes in fuel and moderator composition; this is known as the long-term reactivity effect. It is due to fission products in the fuel and the effect of irradiation on poisons in the moderator.

Subcritical assemblies are also used for investigations into fuel rod configurations, approach to critical experiments etc. One advantage claimed for them is that a wider range of experiments can be performed, than in zero-power critical research reactors. Zero-power reactors also present certain hazards not present with subcritical assemblies, as well as being more expensive.

Installed in the new laboratory of Northeastern University, Boston, is a $15,000 sub-critical assembly designed by Nuclear-Chicago, shown here together with a reactor simulator and radiation counting instruments. The fission process in the assembly results in a multiplication of the neutron flux by a factor of approximately seven

NEWS

- The USSR is not satisfied with either the quality or the rate of scientific and technical training. According to the vice-president of the Soviet Academy of Sciences, M. Lavrentyev, although the number of qualified scientists have increased to 316,000 in 1959 compared with the 10,000 of 1913, there will be an acute shortage unless most resolute and urgent measures are taken.
- Euratom, the UKAEA and the USAEC are pooling their translation efforts, especially those concerned with Russian and Japanese articles. Existing translations, and those planned, are now listed in a monthly bulletin, published by the central information office 'Transatom' in Brussels.
- A centralized university-wide radiation control programme, under the supervision of a Radiation Control Committee, was started in June at the University of Florida. Dr Dunavant, the Radiation Control Officer, is concerned with making the programme second to none. At the Massachusetts Institute of Technology where there are about 50 laboratories using radioactive material in significant amounts, radiation protection is in the hands of a Radiological Safety Office, a division of the Occupational Medical Service.
- Closed-circuit television as an aid to teaching was recently demonstrated by Pye. Linking by microwave equipment, science lessons at a Middlesex grammar school were transmitted direct to a secondary modern school two miles away.

COURSES

International

- Organized by the ENEA and designed for the teaching staffs of universities and higher technical colleges, are two international seminars on nuclear energy, with a capacity for 50 applicants. The Harwell seminar takes place from July 10–21; that at Saclay from June 26–July 7. Details from the OEEC, 38 Boulevard Suchet, Paris 16e.
- Two radioisotope training courses sponsored by the IAEA are in progress. An 8-weeks course with the stress on soil and plant aspects of agricultural and forestry research is running at Wageningen in the Netherlands. For students from Middle East countries, a general introduction to techniques is being given at Cairo's National Radioisotope Centre.

U.K.

Northampton College of Advanced Technology, London Short course on Nuclear Power Plant Design, May 1–12, 1961. Fee: £21.

Lanchester College of Technology, Coventry National Certificate Courses in Applied Physics—S1, S2 and S3 years, Ordinary. Fee: £3 per session ; AO conversion year for Higher National, for GCE 'A' level physics and mathematics. Fee: £3 2s per session; A1 year. Fee: £3 2s per session. Commencing September, 1961.

Borough Polytechnic, London Some problems of Technical Writing — a course of six lectures on Wednesday evenings, commencing April 26. Fee: £1.

Points from Papers

reports, meetings, conferences

RULES FOR NUCLEAR SHIPS

A recent paper read to the Joint Panel on Nuclear Marine Propulsion discusses various aspects of the 'Provisional Rules for Nuclear Ships' published by Lloyd's Register of Shipping. These rules, with their added factor of safety, are related to the hull design, longitudinal strength and constructional materials. The special hull requirements are outlined of a design for a nuclear powered passenger ship. The authors regard such a ship as a feasible proposition. It is probable, they state, that such vessels would prove to be at least comparable with conventional liners in so far as speed, passenger accommodation and machinery space are concerned. Also in the first part of the paper the requirements for collision and grounding protection are explained.

The second part of the paper deals with specifically nuclear and plant aspects. A design is given of a reactor pressure vessel and containment which illustrates the proposed rules for pressure components. The paper examines the problems of defuelling, effluent disposal and briefly surveys other reactor requirements such as afterheat removal, control instrumentation etc.

Lloyd's Register of Shipping Rules and Nuclear Ships. J. M. Murray and H. N. Pemberton. Lloyd's Register of Shipping. Paper read to the Joint Panel on Nuclear Marine Propulsion. 18 pp.

CONCRETE SHIELDS

The literature on thermal stresses in reinforced concrete is scanty. This report and discussion goes some way to redressing this state of affairs. The impression left, however, is that theory is still not able to predict accurately what happens in practice.

Stresses in reinforced concrete shields for nuclear reactors. W. Bonsall. **Paper 6626.** Proc. Instn. Civil Engnrs, vol. 16 pp 259-270, July 1960. Discussion vol. 18, pp. 211-218, Feb. 1961.

DOSE-RATE METERS

This instrument is designed to give a measurement of gamma dose-rate on the ground due to radioactive fall-out with an indication unit in an underground post. The meter, Remote Reading Dose-rate Meter Type 1532, measures dose-rate in the range 0·1–500 r/h, is battery operated and is capable of 300-h continuous operation without battery replacement. The current from the ionization detector is led by co-axial cable to the input circuit of a single stage electrometer valve circuit. The ion chamber current is balanced by the electron grid-current, the anode current being proportional to the log of the ion chamber current.

A second instrument, Trainer Type 1532, is described which simulates the type of response expected to be obtained by the remote-reading instrument.

A remote reading gamma dose-rate meter and a training instrument for civil defence. K. E. G. Perry and J. E. Maddock. AERE Harwell. **Report AERE R 3532.** 22 pp. Available from HMSO 4*s* 6*d*

NOBLE METAL THERMOCOUPLE

The need to replace Chromel-Alumel thermocouples for high temperature and control in the aircraft engine industry has led to the development of a new alloy, Platinel, which should find application in reactors. It is composed of gold, palladium and platinum, resists oxidation at high temperatures and has thermoelectric properties remarkably similar to Chromel-Alumel in the 300–1300°C range. This means that if Chromel-Alumel couples are replaced by ones using the new metal there will be no need for any instrumentation change. Also, as the thermoelements are of precious metal they will have a longer useful life.

Platinel—A Noble Metal Thermocuople. D. J. Accinno and J. F. Schneider. Engelhard Industries, Inc. 14 pp. Copies available from *Nuclear Power*.

DEGRADATION OF DILUENTS

It has been found that tributyl phosphate produces traces of mono- and dibutyl phosphoric acids in the presence of fission product beta and gamma radiation and also by thermal de-alkylation in the presence of aqueous nitric acid. The degradation of odourless kerosene and a range of alternative diluents, in the presence of 20% TBP, by mixtures of nitric and nitrous acids at 60–70°C, is reported in this paper. The amount of degradation has been reliably measured by a retention test using hafnium with Hf-181 as a tracer. The purification of the degraded solvent is also discussed.

Degradation of diluents used with TBP in solvent extraction. B. O. Field and E. N. Jenkins. AERE Harwell. **Report AERE R 3507.** 23 pp. Available from HMSO 4*s*

MHD RESEARCH IN THE UK

The main emphasis in the magneto-hydrodynamic work being undertaken in the UK has been placed on the understanding of the ionization phenomena and the processes taking place in a plasma. The experimental effort is mainly directed towards the demonstration of effects and the development of measurement techniques. The author reports on the work being carried out at various centres and suggests that in two to three years time it should be possible to make a realistic assessment of the future of magneto-hydrodynamic power generation.

MHD power research in the UK. B. C. Lindley. C. A. Parsons & Co. Ltd. Nuclear Research Centre. **Report NRC 61-10.** 21 pp. Paper prepared for the 2nd Symposium on Engineering Aspects of Magnetohydrodynamics, University of Pennsylvania, March 1961. Copies available from the author.

FAST NEUTRON FLUX

An essential requirement in the study of reactor systems is a knowledge of the fast neutron flux. This report discusses the theoretical and experimental aspects of measuring fast fluxes using the S-32 (n, p) P-32 reaction. Special attention is given to the problem of measuring the flux in regions where there are varying levels such as are found in shield surveys. Recommendations are also made for suitable methods to be used during the commissioning trials of power reactors.

The measurement of fast neutron flux using the S-32 (n, p) P-32 reaction. B. H. Parker. AERE Harwell. **Report AERE R 3443.** 35 pp. Available from HMSO 5*s* 6*d*

CESIUM-137 IRRADIATOR

During the past year a 12,000c Cs-137 research irradiator has been designed and installed at the Georgia Institute of Technology. The basic design is a slight modification of the Notre Dame Co-60 irradiator.

Annual Technical Status Report No. 1, Project No. A-446-6, Cesium-17 Research Irradiator. R. W. Carter and R. C. Palmer. Engineering Experiment Station, Georgia Institute of Technology. 10 pp. Copies available from the authors or *Nuclear Power*.

New Reports

A general purpose two channel coincidence unit AERE type no. 2013A. F. H. Wells, G. L. Godfrey and A. K. Barlow. AERE Harwell. **Report AERE R3292.** 18 pp. Available from HMSO 2*s* 6*d*

On the instability of circular gas-lubricated bearings. V. N. Constantinescu. **Harwell Report AERE Trans. 856.** (From Studii si Cercetari Mecanica Aplicata, 1959, **10,** (1), 117-140). Available from Harwell library.

General Technical Conditions for Nuclear Ships. Bureau Veritas. Guidance note (in French) available from the British Central Office of Bureau Veritas, Old Broad Street, London, EC2.

Experiments on the determination of the maximum and minimum values of the heat transferred between a metal surface and boiling water. S. Nukiyama. **Harwell Report AERE Trans 845.** (From Journal of the Society of Mechanical Engineers, Japan, 1934, **37,** 367-374). Available from Harwell library.

Design of irradiation experiments. J. R. Atkinson and S. Rigg. The Institution of Mechanical Engineers. **Paper 33/60.** 20 pp.

Index to ten-year civilian power reactor program. Index to the TID-8518 series. 13 pp. Available from OTS $0.15 or depository library.

Precise surveying in the construction of 'Nimrod' the 7 GeV proton synchrotron. D. W. Berry. Hilger and Watts Ltd. Paper presented to the Royal Institution of Chartered Surveyors. 29 pp.

Changes in the properties of materials due to irradiation with particles and photons. K. Sagel. 'Metall' vol. 12, no. 5, pp. 353-362, 1958. Translated by R. Hardbottle AERE Harwell. **Report AERE Trans 858.** Available from the Harwell library.

Crystal counters of cadmium sulphide with a high-frequency electric field. M. Borisov and M. Marinov. **Harwell Report AERE Trans 857.** (From Doklady Bolgarskoi Akedemii Nauk, 1958, **11,** (3), 169-172.) Available from Harwell library.

Cross Section by GRACCHUS

SO WORK has now started in the United States on a pressurized water, natural circulation reactor which will be a prototype for a simplified submarine propulsion plant. This disclosure by AEC Commissioner Robert E. Wilson in the now famed '202' Joint Congressional Committee hearings seems to be an indication that the problem of noisy main coolant pumps—the second noisiest item in US nuclear submarines after the main reduction gears—has not been solved. If you would care to refer to the June, 1960 issue of *Nuclear Power* where I mentioned these 'noisy' submarines, I did point out then that some alternative to the PWR was being considered because of this. One of the advantages of the natural circulation reactor is that in addition to eliminating the main coolant pumps now used, the coolant check valves, pump generators and controls will be discarded. However, the reactor and heat exchangers would have to be larger, though there would be an overall saving in weight. Among the problems that still remain to be solved is that of the flow patterns which may be affected, without forced circulation, by heavy weather. This in turn could, of course, affect power output.

Holy Loch and Polaris missiles have been so much in the news that perhaps a few facts and figures on the now departed submarine *Patrick Henry* may well prove interesting to those of us who have never seen them grouped together. This vessel cost an estimated $100 million—twice that of the *Skipjack* because of its missile carrying capacity. Its core is some 30% larger than that in the *Nautilus* and is capable of a range of some 100,000 miles at full power at a speed above that of *Nautilus* but some five knots less than *Skipjack* on which our own *Dreadnought* is based. This range is a considerable improvement over the first and second *Nautilus* cores which were changed after 62,000 and 93,000 miles respectively. Improvements will bring the range to nearly 150,000 miles.

Our own second nuclear submarine will have a reactor similar to that in *Dreadnought* though some British features have been incorporated. The prototype for this at Dounreay is expected to go critical in mid-1962. Meanwhile, I understand that design studies are proceeding on Britain's fifth nuclear submarine. Work on the third and fourth has been completed, so I am told.

THERE WAS a somewhat Lenten air about the first of the informal discussions arranged by the Nuclear Energy Group of the Institution of Mechanical Engineers recently. The theme was enrichment—the influence of availability upon reactor type and design. Perhaps this was too rich a mixture for one to contemplate before the end of Lent. Whatever the reason, there was a disappointingly poor attendance. This was matched by a thin debate, probably due to the absence of 'big guns' who presumably might have been expected to have some realistic figures about the cost of enrichment. As it was, instead of a positive discussion, there was an informative monologue from a Risley man and lively interpolations from Babcock and Wilcox. I waited in vain for someone to bring up the point made recently by Dr Lyman Fink, general manager of the US General Electric Company's Atomic Products Division, that the USAEC was charging too much for its enriched fuel and should reduce its price. However, the difficulty with any pricing of enriched fuel is that its production is linked with plants producing U-235 for nuclear weapons. Any information is necessarily classified so that it is extremely difficult to assess the true cost of producing the fuel.

THOUGH A book review is not really my province, 'Strictly Birdmanship' or 'How to lay the egg that kills the Golden Goose' is one book I could not ignore. Written by ex-RAF pilot Bernard S. Benson and illustrated by Jack Roberts, this American production is a brilliant series of satirically captioned cartoons—a cross between Potter and Parkinson—on some of the problems in the partnership between government and industry in the area of scientific research and development.

The primary job of every government, the author says, has been to keep everyone busy; the few people who don't understand this basic philosophy and ask stupid questions must be dealt with in a positive way. Hence the author gives a number of useful ploys for emergency use such as: 'But Senator, it was a tremendous buy. We found out what not to do for only three billion dollars—this puts us way out front in the hindsight race.' A ploy to protect against capitalism: 'The task should always exceed the funds. Overrun contracts are proof of shrewd government contracting. This is the way for the Government to get a free ride. What better way for contracting officers to show their bosses that they are on the ball than to get work done for the Government without a fee.'

Another section of the book deals with ploys to protect industry against itself. These must be an essential part of every government employee's repertoire and include: 'If you want to get creative ideas from industry, give a management contract to a large company. This will needle all the other competing companies to come dashing with their new ideas just to show how smart they are. All people are insecure—they love to show off.'

Mr Benson, who emigrated from Britain to the USA at the end of the last war, has done a very good job on this book, though in some parts it is too true to be funny. I am now trying to find a copy of his first book 'Engineermanship' which satirized modern engineering.

'Strictly Birdmanship' by Bernard S. Benson and Jack Roberts; Benson-Lehner Corporation, 1860 Franklin Street, Santa Monica, California; price $3.00.

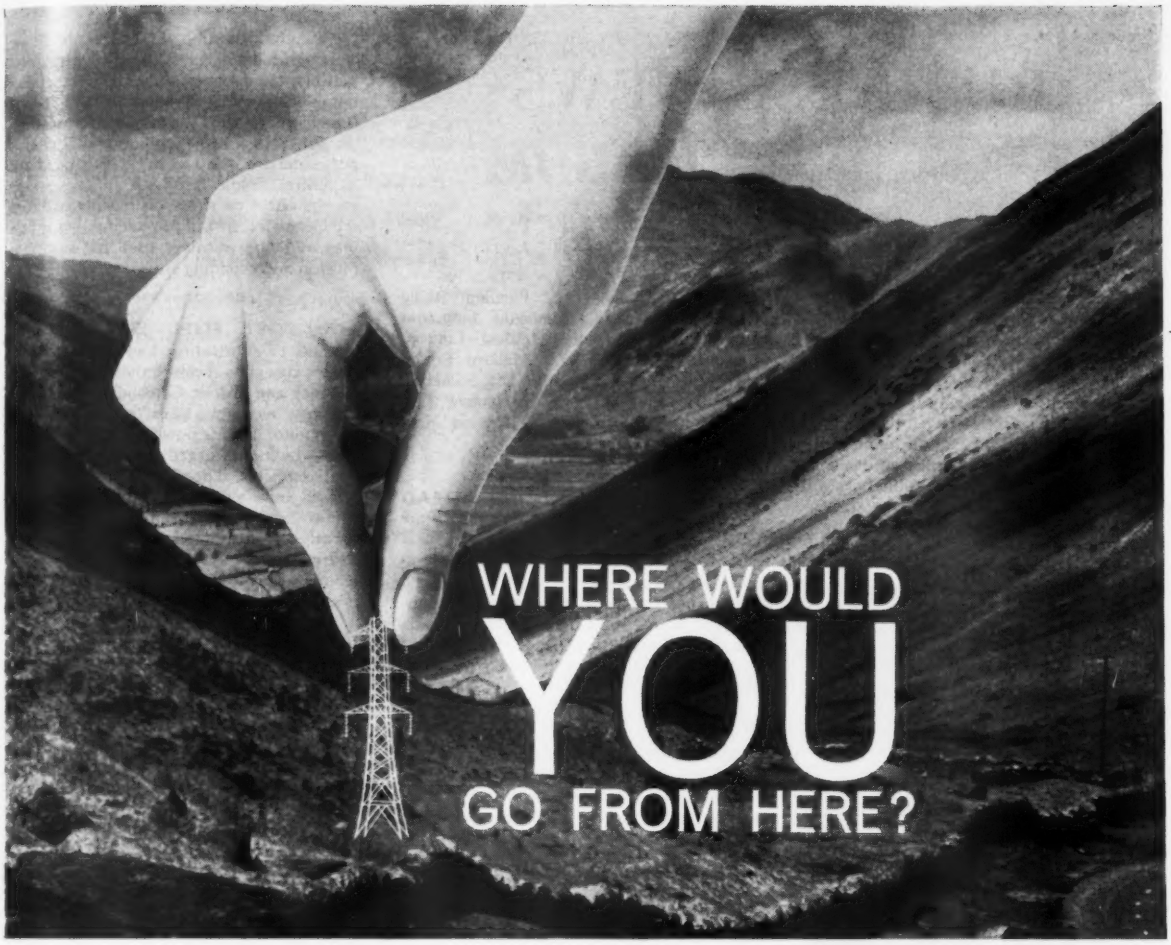
On Record

'. . . we made a substantial investment in a 60,000 kW materials testing reactor at Waltz Mill, Pa. In all frankness, I must say these facilities are not used to capacity and we save money when the plant is shut down.'

Charles H. Weaver, vice-president, Westinghouse Electric Corporation, before the recent Joint Congressional Committee '202' hearings.

'Nuclear research is so fantastically costly that it can only be undertaken by governments—yet we have no indication that HM Government has devoted any serious effort to developing a marine reactor. Is this not a line of research which, in the national interest as well as in the interest of British shipbuilding and shipping, should be vigorously pursued?'

Mr R. Stewart McTier, retiring chairman of the Liverpool Steam Ship Owners Association, at the annual meeting.



Suppose for a moment that you are a wayleave officer working for the Central Electricity Generating Board. Your job is to plot a line bringing new power to an expanding town in the valley over the hill. Where do you go from here? The easiest and cheapest way would be up and across the crest of the hill. But the people in the valley (and the people visiting the valley) will take rather a poor view of that. By-pass the ridge and march down the valley itself? That would involve a three-mile detour, extra expense, and some unsightly angle towers. Bury the cables underground? An attractive idea but an impossibly expensive one, which could raise installation costs 17 times—with inevitable repercussions on the cost of electricity. There is no easy solution. But one must and will be found . . . one that fulfils the double duty which, by Act of Parliament, rests on the CEGB: to provide an efficient and economical electricity supply, while doing everything possible to preserve the natural amenities of the countryside. Please think of this next time you grumble at the towers: they are being carefully planned by men who value the countryside as much as you do.

■ **These advertisements are appearing in the farming and country magazines. The Central Electricity Generating Board thank electrical contractors for their co-operation in the past, and know that they will do all they can to preserve the amenities of the countryside.**

Write for a copy of "Preserving Amenities" to The Central Electricity Generating Board, 83 Winsley Street, London, W.1.

CEGB

the people who make your power in 234 stations and distribute it through the 6677 miles of the National Grid

BUSINESS NEWS

ENGLISH ELECTRIC REPORT An additional comment on the fruitless GEC—**English Electric** merger negotiations (see *Business*, January, p. 108) came in Lord Nelson's address to stockholders at the English Electric Company Ltd's annual general meeting. Referring to the rational use of resources, Lord Nelson pointed out that the company had had discussions with other companies regarding collaboration in many other fields. It was not possible to bring the negotiations with GEC to a successful conclusion but the fact that they were initiated, illustrated that rationalization was constantly under review. Lord Nelson added that the contest between nuclear and conventional thermal power was reaching an interesting phase. Latest indications were that the power cost gap between the two would narrow 'in the next few years'.

ELECTRONIC FIRM SET UP A partnership to manufacture and market advanced electronic and electrical control and intelligence systems has been formed by the electronics sections of **Armstrong Whitworth Aircraft,** a member of **Hawker Siddeley and Co.,** and **Brush Electrical Engineering.** The new concern will be known as **Armstrong Whitworth-Brush.** Two contracts have already been received—one is for radar data link equipment and the other, recording equipment for experiments in the detection of underground nuclear explosions. Brush will be the trading organization for the new partnership which will channel inquiries for equipment to whichever of the two companies has the most suitable facilities.

AGREEMENT MADE VOID The Restrictive Practices Court recently decided that all restrictions in an agreement of the Transformer Manufacturers Association were against the public interest. The agreement, which included price-fixing, was declared void. The Association point out that the decision could only intensify the problems of the industry in the home market. Still more serious was that it must impair their ability to develop successfully in the competitive export market.

SIMA IN MOSCOW Following the success of their exhibition in Moscow in 1960, members of the Scientific Instrument Manufacturers' Association will be present in force at the British Trade Fair, Moscow, from May 19-June 4. Exhibiting will be 19 member firms including **Avo Ltd, Cambridge Instrument Co. Ltd, Cossor Instruments Ltd, Dawe Instruments Ltd, Electronic Instruments Ltd, E.M.I. Electronics Ltd, Elliott Brothers (London) Ltd, Endecotts (Filters) Ltd, Fleming Radio (Developments) Ltd, Goodmans Industries Ltd, Griffin & George (Sales) Ltd, J. Langham Thompson Ltd, Mullard Equipment Ltd, Negretti & Zambra Ltd, Solartron Electronic Group Ltd, Telequipment Ltd, Ultra Electronics Ltd** and **Wayne Kerr Laboratories Ltd.**

IEA EXHIBITION LOOKS AHEAD Looking ahead are members of the International **Instruments, Electronics and Automation Exhibition** Committee who have embarked on a nine-city tour of the Continent. They will tell European manufacturers about the exhibition and encourage them to show their products or at least visit the exhibition which lasts from May 28 to June 2, 1962.

• A contract for the design and manufacture of the electrical propulsion machines and control gear for the second British nuclear submarine has been won by **Laurence Scott and Electromotors.**

• **Davy-Ashmore Ltd** has formed a new subsidiary, **Davy-Ashmore Export Company Ltd,** to manage and develop its overseas selling and engineering organization.

• A new division of **Coventry Compressors** has been formed to deal with problems of penetrating all types of materials used in construction and installation work.

• Substantial reductions in the prices of their entire range of Norbit electronic sub-assemblies has been announced by **Mullard Equipment Ltd.** The cuts range from 42% to 23%.

• **C. A. Parsons & Co. Ltd** is supplying four 142·5 MW main turbo-alternators for the Dungeness nuclear power station.

OVERSEAS

INDIAN LABORATORY ORDER An order to supply complete nuclear instrumentation for analysis purposes has been awarded to the American firm **Tracerlab** by the Nutrition Research Laboratories of the **Indian Council of Medical Research.** The order, which includes several fully-automatic radioisotope counting systems, will make it possible for the Institute's staff to apply the latest tracer techniques in their work.

JAPAN MOVES ON SHIP REACTORS Japanese moves towards developing marine reactors have taken a further step forward. German information on this is to be exchanged under a recently signed agreement between the Japanese **Research Association for Nuclear Ship Propulsion** and **GKSS** (Gesellschaft für Kernergie Verwendung in Schiffbau und Schiffahrt). Technical personnel are likely to be interchanged and in return for the results of Japanese work on the effect of stress on marine reactors, the German firm will provide reports on the OMR and pool reactors used for ship propulsion and shielding studies.

LOW-COST FUEL ELEMENTS A method of fabricating fuel elements at a lower cost has been announced by the **Babcock and Wilcox Company** of the USA. The new technique calls for the vibration of uranium dioxide powder into thin hollow rods which are forged, or swaged, to the final diameter. The UO_2 powder is compressed to the required density in the process. The company says that because they show promise of being less expensive to make and have a greater output and longer core lifetime potential, the new elements represent a step toward more economical nuclear power.

GE's ELECTRONICS SECTION A Nuclear Electronic Products Section (NEPS) has been set up by **GE** of the US. It will be responsible for the development, design, manufacture and marketing of electronics systems and components for the control of reactors plus other specialised instrumentation used in the nuclear field.

DUTCH ATOM FORUM A number of Dutch industries, together with the **Reactor Centrum Nederland,** have set up a Netherlands Atom Forum. Its object is to publicise developments in nuclear energy and the activities of Dutch industry and institutes. It will represent Holland at **Foratom,** the Forum Atomique Européen.

• Nuclear insurance history was made in Japan when the first policy covering two reactors—the 50 kW JRR-1 and the 10 MW JRR-2—was signed between the **Atomic Energy Insurance Pool** and the **Japan Atomic Energy Research Institute.**

• **Tracerlab's** Reactor Monitoring Centre at Richmond, California, is to supply the radiation monitoring instrumentation for the Portable Medium Power Plant, PM-1, a small PWR.

• **Oak Ridge National Laboratory** is to expand its facilities for the separation of stable isotopes six-fold.

• All **Vitro Italiana** Milan activities have been consolidated at a new address—Via Baldissera 5, Milan.

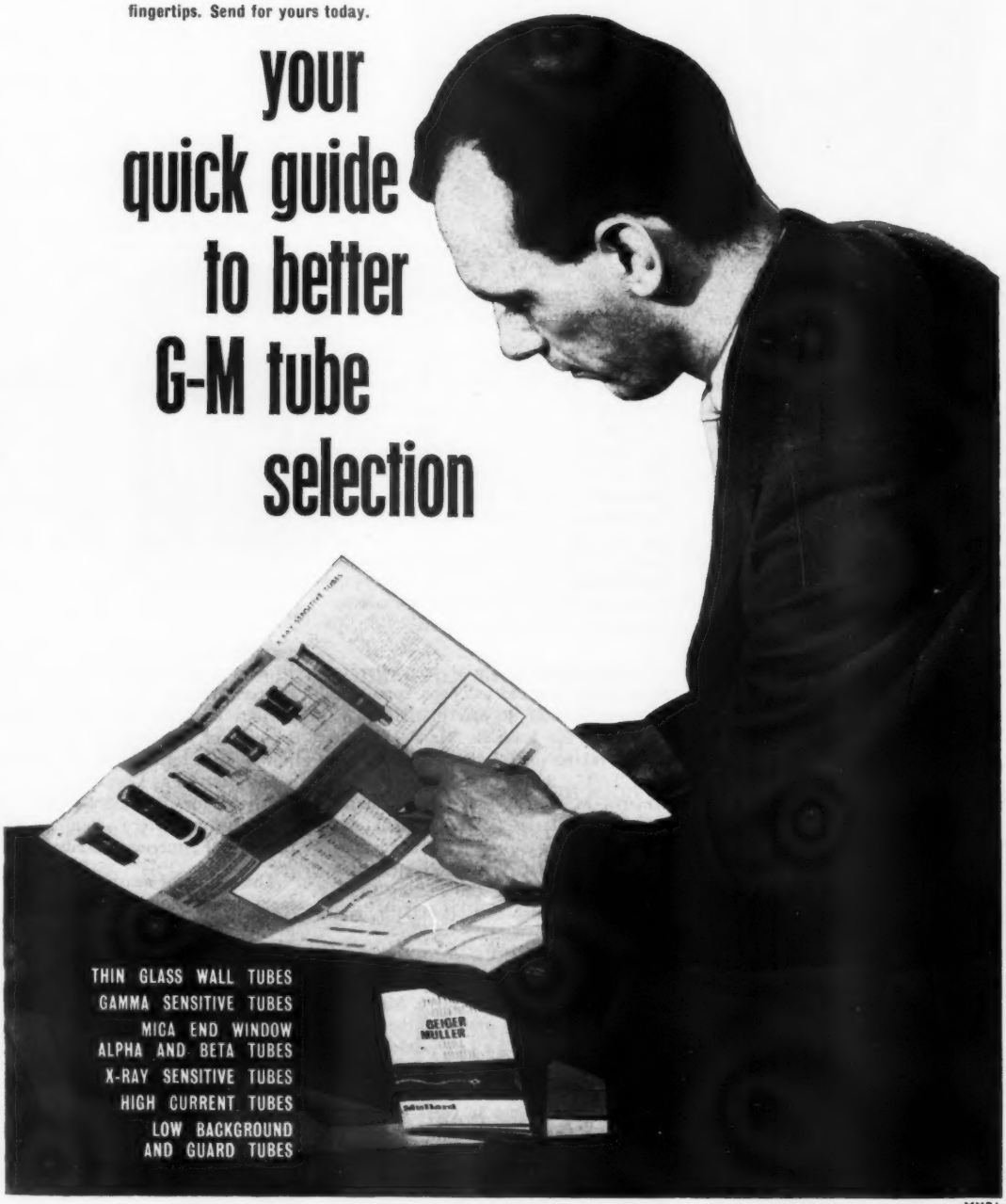
• **Tokyo Shibura Electric Company** has revised its turbine generator licensing agreement with **GE** of the US to include manufacturing this equipment for nuclear power plants. The previous agreement covered conventional power plants.

Now, in ready-reference form, comes a new guide to the complete range of Mullard halogen quenched G.M. tubes. It is arranged to help you evaluate the most suitable tube for any application quickly and easily. Whether you are designing equipment or considering tubes for replacement, you'll find it saves time to have a copy at your fingertips. Send for yours today.

Mullard X-RAY DIVISION

MULLARD LIMITED · X-RAY DIVISION · New Road · Mitcham Junction · Surrey · England

your quick guide to better G-M tube selection



THIN GLASS WALL TUBES
GAMMA SENSITIVE TUBES
MICA END WINDOW ALPHA AND BETA TUBES
X-RAY SENSITIVE TUBES
HIGH CURRENT TUBES
LOW BACKGROUND AND GUARD TUBES

MXR1

Sir Ben Lockspeiser, the chairman (standing) opens the first meeting of the recently-formed Nuclear Energy Industry Standards Committee of the British Standards Institution. To his left is Mr G. Weston, technical director, and on his right is Mr H. A. R. Binney, director of the BSI

People

by John Radford

A FEMININE touch is being brought to the American Board of Health Physics by the appointment of **Dr Elda E. Anderson** of Oak Ridge National Laboratory as its chairman. Dr Anderson is a past president of the Health Physics Society; she is also a member of the American Physical Society, American Nuclear Society and Industrial Hygiene Society. Her primary field of interest is the education and training of health physicists and her work on the Board will be concerned with establishing uniform standards for radiation protection specialists. The Board itself was created in 1960 by the Health Physics Society for this purpose.

From Ekco Electronics comes the news of new board appointments and the election of **Mr E. B. Thompson,** their sales manager, as chairman of the

E. B. THOMPSON J. CORBISHLEY
Ekco appointments

Nucleonics Group of the Scientific Instrument Manufacturers' Association. The board appointments are that of **Mr J. Corbishley,** a director and financial controller of E. K. Cole Ltd, and **Mr S. A. Clodd,** who controls Ekco Factories and was recently appointed a director of E. K. Cole Ltd. Chairman of the board is **Mr A. W. Martin** with **Mr A. J. Brunker** and **Lord Waleran** as the other board members.

One of the pioneers of the welding industry, **Mr H. Martin,** home sales manager of Murex Welding Processes Ltd, has retired after 38 years' service. His interest in welding began as long ago as 1917 at the old Great Eastern Railway Works where he was originally apprenticed. Since that time, Mr Martin has become well known as a lecturer and has served on many British Standards Institutions committees. His successor is **Mr R. E. H. Bell,** assistant home sales manager for the past ten years.

A new group financial controller to Metal Industries Ltd has been appointed in the person of 46-year old **Mr E. F. Coppock.** He succeeds **Mr P. Jardine** who is taking up full-time directorships with J. G. Statter and Co Ltd and Minerva Mouldings Ltd, two Metal Industry subsidiaries. Mr Coppock has had many years' experience in companies engaged in electrical and electronic engineering including the Plessey Company, Elliott Brothers (London) and Evershed and Vignoles.

Five months after joining D. Napier & Son Ltd as a special executive, **Mr P. J. Daglish** has been appointed to the board as commercial director. A former manager of the English Electric Company's Aircraft Equipment Division, 42-year old Mr Daglish spent 16 years with that company. During that time he made rapid progress, becoming manager of the standards and specification section two years after joining the firm; a year later he became deputy chief development engineer and in 1950 was appointed assistant to the chief engineer.

The head of the French Atomic Energy Commission's Division of Large Research Reactors, **Dr Pierre Louis Balligand,** is to succeed **Dr Hubert de Laboulaye** as deputy director in charge of the Department of Technical Operations of the International Atomic Energy Agency. Like so many of the French nuclear scientists, Dr Balligand is a graduate of the Ecole Polytechnique. One of his main concerns has been reactor safety regulations and Dr Balligand was responsible for the development and application of the first provisional safety measures for experimental reactors at the French research centre at Saclay. Dr de Laboulaye, another French scientist, left the IAEA at the end of March and returns to a senior position with the French AEC.

Another IAEA appointment, this time in an advisory capacity, was that of **Mr David P. Herron,** Director of Nuclear Technology at Advanced Technology Laboratories (ATL). He was invited

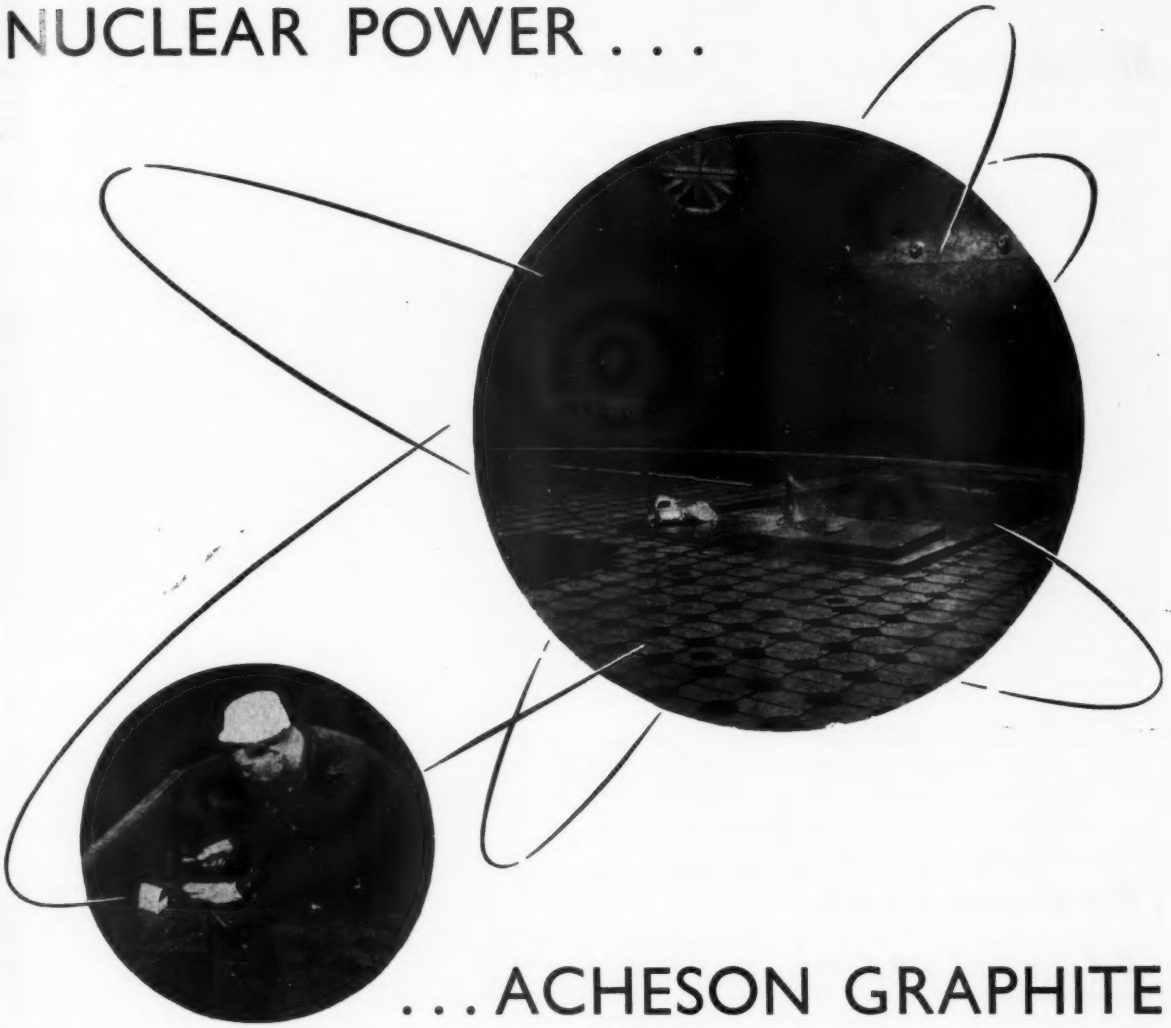
Dr P. BALLIGAND DAVID P. HERRON
IAEA experts

recently by the IAEA as a visiting expert to assist and advise on the development of comparative nuclear power costs in various countries and of an up-to-date analysis of the status of current nuclear power plant technology. Mr Herron previously served as Director of Operations Analysis for the US Atomic Energy Commission before joining ATL, a division of American-Standard.

The ending of nearly five years secondment to the Atomic Energy Authority at Harwell and Winfrith comes for **Mr K. Maddocks** who has been appointed chief project engineer by his employers, Yarrow & Co Ltd. He commences his duties at the beginning of May; the transfer also implies the ending of his service with the Yarrow-Admiralty Research Department.

Mr A. Broomhead is now deputy managing director of Thos. Firth & John Brown Ltd and **Mr F. Wortley,** a director, has been appointed general works manager.

NUCLEAR POWER . . .



. . . ACHESON GRAPHITE

TRADE MARK

In its work as a neutron brake the pile moderator performs an exceptional role in the reduction of neutron velocities to thermal values for the continued promotion of the natural uranium fission process. In this function 'Acheson' Graphite is playing a supremely vital part. In close collaboration with the United Kingdom Atomic Energy Authority 5,000 tons of 'Acheson' Graphite conforming to an exceptionally strict specification for purity were supplied for the Calder Hall 'A' reactor.

Many thousands more tons of 'Acheson' Graphite in nuclear qualities are in train for Britain's Atomic Power Stations.

ACHESON

TRADE MARK

GRAPHITE

The term 'ACHESON' is a registered trade mark

BRITISH ACHESON ELECTRODES LTD., WINCOBANK, SHEFFIELD **PHONE: ROTHERHAM 4836**

Diary

20 APRIL–4 MAY
Engineering, Marine Welding and Nuclear Energy Exhibition, Olympia, London

28 APRIL
Ion Exchange, T. R. E. Kressman, Carlisle, 7.15 p.m. Meeting, Society for Analytical Chemistry

3–4 MAY
Symposium on **structural processes in creep,** London. Details, Institute of Metals, 17 Belgrave Square, London, SW1 and Iron and Steel Institute

8–11 MAY
Industrial finishes exhibition and convention, Earls Court, London. Details, Scientific Surveys Ltd, 97 Old Brompton Road, London, SW7

9–10 MAY
Standards engineers conference, London. Details, British Standards Institution, 2 Park Street, London, W1

10–12 MAY
International conference on **materials handling,** Prince of Wales Hotel, Southport. Details, H. M. C. Harwood, 32 Watling Street, London, EC4

15–19 MAY
Conference, **Heat recovery from industrial furnaces** including exhibition, Bournemouth. Details, Institute of Fuel, 18 Devonshire Street, Portland Place, London, W1

29 MAY–2 JUNE
Conference on **property changes in reactor materials and radiation damage,** Bristol. Details, Central Electricity Generating Board, Berkeley Nuclear Laboratories, 7 St Stephen's Avenue, Bristol 1

30 MAY–2 JUNE
Radio and Electronic Components Show, Olympia, London

5–8 JUNE
Drawing office equipment and materials exhibition, Royal Horticultural Society, New Hall, Westminster. Enquiries, UTP Exhibitions Ltd, 9 Gough Square, London, EC4

Future months

28 AUGUST—1 SEPTEMBER
Symposium on **radioactive metrology,** Oxford. Details, Dr B. W. Robinson, Superintendent Applied Physics Division, National Physical Laboratory, Teddington, Middlesex

30 AUGUST—6 SEPTEMBER
Annual meeting, British Association for the Advancement of Science, Norwich. Details, Secretary BAAS, 19 Adam Street, London, WC2

SEPTEMBER (date later)
Convention, **The impact of nuclear development on electricity and on instrument techniques,** London. Details, Institution of Electrical Engineers

OVERSEAS

26–27 APRIL
Conference on **materials for high temperatures,** Cleveland. Details, American Institute of Mining and Metallurgy, 29 West 39th Street, New York 18, USA

2–5 MAY
OEEC symposium on **criticality control in chemical and metallurgical plant,** Karlsruhe. Details, European Nuclear Energy Agency, 38 Boulevard Suchet, Paris 16e, France

3–5 MAY
Atomic energy in space, Oak Ridge, Tennessee. Jointly sponsored by Oak Ridge National Laboratory and the American Rocket Society, Chairman, C. J. Wang, Aerospace Corporation, 5500 El Segundo Blvd, Los Angeles 45, California, USA

3–10 MAY
IAEA symposium on **detection and use of tritium** in the physical and biological sciences, Vienna, Austria

3–13 MAY
Fifth US World Trade Fair, New York, USA

5–6 MAY
Neutron physics, American Nuclear Society-Rensselaer Polytechnic Institute meeeting, Troy, New York, USA

7–10 MAY
American Institute of Chemical Engineers meeting on **fluid mechanics, radioactive substances in process control** etc, Cleveland, USA. Details from 25 West 45th Street, New York 36, USA

8–10 MAY
Fourth National Instrument Society of America **Power instrumentation** symposium, Chicago. Details, ISA, 313 Sixth Avenue, Pittsburgh 22, Pa, USA

9–13 MAY
Inter-American Nuclear Energy Commission, third meeting, Washington, DC, USA

9–17 MAY
MESUCORA international exhibition on **measurement, control, regulation and automation,** Paris. Details, MESUCORA, 40 rue du Colisée, Paris 8, France

15–20 MAY
IAEA **Nuclear electronics** conference, Belgrade, Yugoslavia

16–17 MAY
First annual meeting and conference, Canadian Nuclear Association, Toronto, Ont, Canada

Industrial Literature

Control circuits. Mullard's range of building bricks provide the basic functions—logic, memory and counting—and enable users to construct their own control systems quickly and efficiently. A recent catalogue covers the Combi element and Nor-bit circuit blocks and a range of preset counting units, one type for industrial control and the other for high speed applications up to 100,000 pulses/s.

★ 247

Glass applications. Corning's ' This is glass ' is available in a revised edition. Apart from reviewing many applications, and tabulating the properties of selected glasses and glass-ceramics, a preview is made of future use.

★ 248

Industrial chemicals. Albright & Wilson have published a new general chemicals catalogue that lists some 350 products in alphabetical order, giving formula and physical form.

★ 249

Electrical machinery. BEAMA's 50th annual report, 1960-61, lists the year's publications issued by the International Electrotechnical Commission, and the new and revised British Standards in which the Association has co-operated.

★ 250

Engineering materials. Tube Investments recently issued a guide to the larger home companies of the 65 precision tube, aluminium steel, engineering and electrical firms that come within the group. Under each company is the range of products available.

★ 251

Aluminium pipes. Aimed at nuclear applications, a new catalogue has been issued by Svenska Metallverken specifying pipes, fittings and flanges. Tables are also given of chemical and physical properties, calculation of strength and welding procedures.

★ 252

X-ray microanalysis. List 177/2, recently published by Cambridge Instruments, describes fully their Microscan analyser. As well as static probe point-by-point quantitative microanalyses, the instrument can also be used to scan the surface of the specimen over an area up to ½ mm × ½ mm.

★ 253

Dislocations in metals. A technique developed at the AEI Research Laboratory, Aldermaston, using modern electronic microscopes, is playing an important part in physical metallurgy. An article appears in the March issue of 'AEI Engineering '.

★ 254

Weld tests. An article in the January issue of ' Solus Schall News ' describes the technique of automatic ultrasonic scanning where three probes are used working simultaneously.

★ 255

Electronic valves. The 1961 edition of English Electric's quick reference brochure, containing abridged data for all EEV valves, is now available.

★ 256

Nuclear instrumentation. Hamner's new 40 page catalogue of counting equipment-analysers and detectors is intended as an aid to selection and provides complete technical specifications and a guide to applications.

★ 257

Valves for corrosives. IV Pressure Controllers are now handling the Bascodur valves that use for linings a thermo-setting synthetic material possessing good corrosion resistance. A leaflet describes the specifications of gate, angle and globe valves and tabulates the chemical stability against many acids, alkalis, salt solutions and organic amalgamations.

★ 258

Alloy steels. As a guide to the range of alloy steels that can be supplied by Hadfields for structural and general engineering, publication 463 tabulates those steels that conform to BS970, and the properties that can be expected after heat treatment.

★ 259

Ceramic materials. Because of its ability to withstand high temperatures and maintain its mechanical strength, its resistance to abrasion and chemical attack, and its hardness, Sintox, a high-alumina ceramic material, is attractive to the mechanical engineer. Lodge Plugs' new brochure gives details of chemical structure, properties and applications.

★ 260

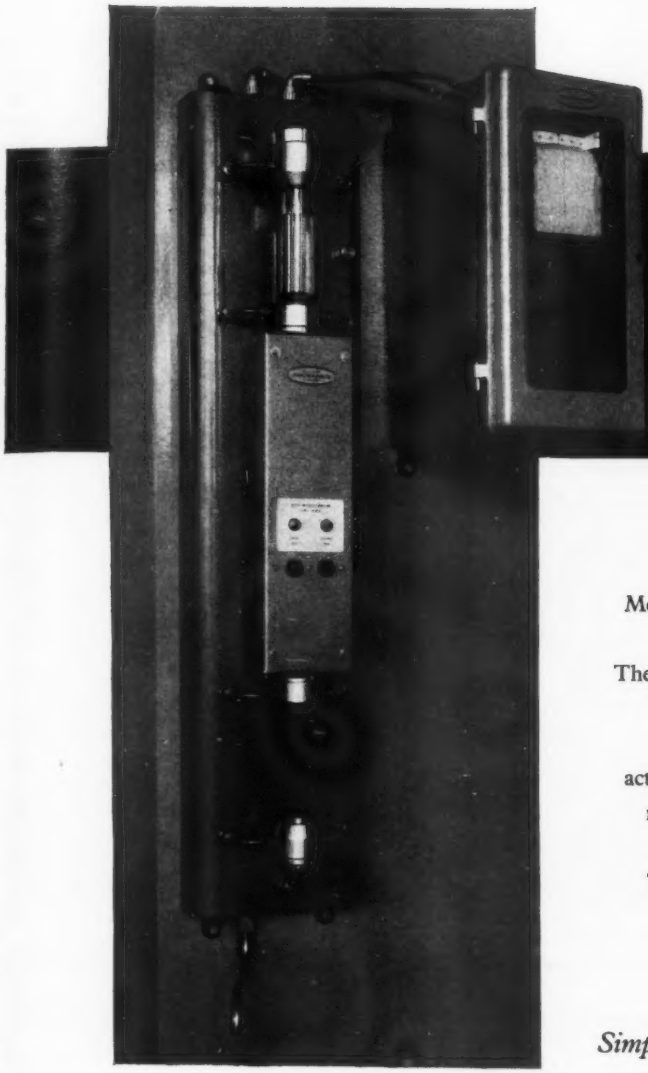
Fluid power equipment. The first of a new series from Hydraulics & Pneumatics, intended primarily for management, is a pamphlet that outlines the various types of fluid power equipment available, and the general functions they perform.

★ 261

★ *For further information on any item, circle the appropriate number on the reply card facing page 106*

ELLIOTT NUCLEONICS LIMITED

ANNOUNCE



another new instrument

Adding to our range of installed Health Monitoring Instruments, we now introduce the High Sensitivity Water Monitor ND.2151. The equipment measures and records the activity of solid radio-isotopes dissolved in water and has a sensitivity such that a specific activity for drinking water well below the maximum permissible level for mixed fission products can be detected. The measuring circuits employ transistors ensuring a high degree of reliability.

Simple to use — reliable in operation

RANGE OF PRODUCTS & SERVICES

REACTOR CONTROL INSTRUMENTS · PROCESS CONTROL INSTRUMENTS
HEALTH MONITORING EQUIPMENT · DATA HANDLING & COMPUTING EQUIPMENT
CONTROL ROD MECHANISMS · REACTOR ANALOGUE COMPUTERS & SIMULATORS
FLUX SCANNING EQUIPMENT · DESIGN DEVELOPMENT AND SYSTEM ENGINEERING

INSTRUMENTATION & AUTOMATION ENGINEERS TO THE NUCLEAR INDUSTRY

ELLIOTT NUCLEONICS LIMITED
Century Works, Lewisham, London SE13 TIDeway 1271

EA A member of the Elliott-Automation Group

ELLIOTT nucleonics LIMITED

EN.1

Circle No 52 on reply card for further details

Oxford Library of the Physical Sciences

Three New Volumes

Electromagnetic Structure of Nucleons

S. Drell and F. Zachariasen

A critical review and analysis of recent studies of the electromagnetic structure of nucleons. Chapter I defines electromagnetic form factors precisely. Chapter II discusses the different types of experiments which have given information on these form factors with emphasis on theoretical assumptions and approximations used in analysing experimental numbers. Chapter III deals with recent dispersion theoretic analyses of the form factors, and Chapter IV discusses the validity of quantum electrodynamics showing how possible deviations in this theory alter nucleon form factor analyses.

Text-figures 12*s* 6*d net*

★ 262

The Fundamental Atomic Constants

J. H. Sanders

The accepted values of the atomic constants *e*, *h*, *m*, *N*, and *c* and related quantities are derived from the results of high-precision measurements. These experiments are here described in detail, and a brief explanation of the method of deriving the best values of the constants from the results is given. A background of early experiments involving direct and indirect determinations of the constants is presented and a chapter is devoted to the measurement of the velocity of light. The book should be useful to both undergraduates and post-graduate workers.

Text-figures 10*s. net*

★ 263

Nuclear Photo-Disintegration

J. S. Levinger

'The author is to be complimented for providing, in such a condensed yet comprehensible form, an excellent overall picture of the state of the subject, and current thinking in it.'

NUCLEAR POWER *Paper covers* 15*s net*

★ 264

International Series of Monographs on Physics

The Principles of Nuclear Magnetism

A. Abragam

The purpose of this book is to give a consistent description, on a unified basis, of the various aspects of nuclear magnetism. Emphasis throughout is on clarity and rigour rather than on the abundance of factual and bibliographical data. The outlook is mainly theoretical, but a large amount of experimental evidence is included.

Illustrated 84*s net*

★ 265

Oxford University Press

Book Reviews

Direct generation in the USA

This book is the first to provide a survey of direct generation research in the United States; it consists of papers presented at a Special MIT Summer Program in July 1959. The scientist, familiar with developments in this field, will be disappointed to find that most of the papers are reprints. The new worker, unless he is conversant with allied technologies, may find the collection of papers a little confusing, since there is no attempt to provide a homogeneous story.

The first eleven papers report theoretical and experimental studies of thermionic engines, classified into those which operate under high vacuum and rely on auxiliary fields or close-spacing of electrodes to eliminate the space charge effect, and those in which space-charge neutralization is achieved by the introduction at low pressure of a readily-ionizable gas, such as caesium vapour. Energy conversion performance theories are developed; these illustrate that the mechanism of the vacuum diode is well established but that the processes in a gas-filled system are less well understood. There is little discussion of the design of practical systems and, although the attractive concept of a thermionic nuclear fuel element is outlined, the problems associated with the additional function (that is, of direct electricity production) of such a fuel element are not evaluated.

There are only two papers on magneto-hydrodynamic energy conversion. In the first, by Rosa and Kantrowitz of the Avco Corporation, emphasis is placed on the development of high-temperature materials which will have a satisfactory life when subjected to high-temperature high-velocity gas flow. The second, by Carabateas of the Massachusetts Institute of Technology, is a theoretical analysis of a plasma heat engine.

Nine papers on thermoelectric devices follow. The 'Review of Thermoelectric Effects', by F. E. Jaumot of the General Motors Corporation, is a particularly good introduction to thermoelectric power, and includes 117 references. Papers on the basic thermo-dynamics and detailed design of devices are included, together with papers on measurement techniques and experimental data on thermoelectric semiconductor materials.

The final paper is on 'Fuel Cells as Energy Converters', by J. F. Yeager of Union Carbide. Although a distinction might be drawn between 'direct conversion of heat to electricity' and the action of a fuel cell in converting chemical to electrical energy, the inclusion of this contribution provides a useful introduction to fuel cells.

B. C. Lindley

Direct Conversion of Heat to Electricity edited by J. Kaye and J. A. Welsh, Wiley, New York and London, 1960 344 pp, Price 70s.

New books

- *Proceedings of the International Conference on Nuclear Structure* edited by D. A. Bromley and E. W. Vogt University of Toronto Press 1960 Price $16·75

★ 270

- *Proceedings of the VIIth International Cconference on Low Temperature Physics—1960* University of Toronto Press 1960 Price $12·50

★ 271

- *Proceedings of the International Conference on Nuclidic Masses* edited by H. E. Duckworth University of Toronto Press 1960 Price $5

★ 272

- *Handbook of the Federation of Civil Engineering Contractors 1960-61*, London 1961 Price 12s 6d

★ 273

- *NMR & EPR spectroscopy*—Varian's 3rd Annual Workshop, California, 1959 Pergamon, Oxford 288 pp Price 80s

★ 274

- *Kinematics of nuclear reactions* by A. M. Baldin, V. I. Gol'danskii, and I. L. Rozenthal (translated from the Russian) Pergamon, London 1961 303 pp Price 42s

★ 275

- *Radioactivation analysis* Proceedings of an IAEA symposium, Vienna, June 1959 Butterworths, London 1960 141 pp Price 30s

★ 276

- *Translation from Russian for scientists* by C. R. Buxton and H. S. Jackson Blackie, London and Glasgow 1960 299 pp Price 30s

★ 277

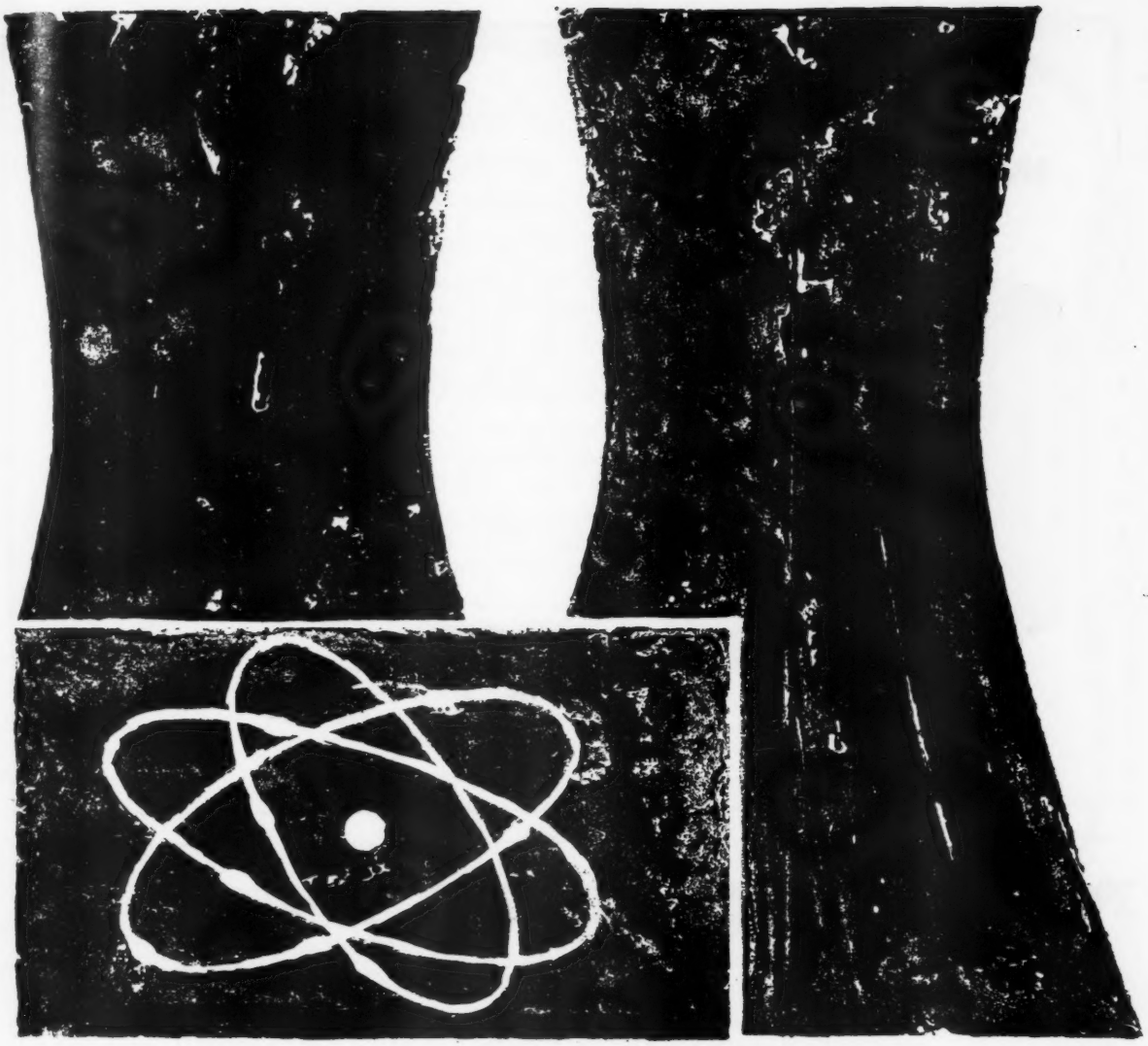
- *Year book of the Physical Society—1960* London Price 13s 4d

★ 278

- *Fast reactor cross sections:* a study leading to a 16 group set by S. Yiftah, D. Okrent, and P. A. Moldauer Pergamon, London 1960 130 pp Price 35s

★ 279

★ *For further information on any item, circle the appropriate number on the reply card facing page* 106.



ARGUMENT FOR ALUMINIUM Aluminium is indispensable in nuclear engineering - for cladding reactors, for fabricated pipework and heat exchanger tubes, for such diverse ancillary equipment as glove-boxes, remote control gear and treadplate. **IMPALCO**, backed by ICI and ALCOA, has both the production facilities and the technical know-how to meet the needs of this exacting industry. Wherever there is an argument for aluminium's lightness, durability, good conductivity, ease of handling - contact **IMPALCO** through your nearest ICI Sales Office.

impalco aluminium

Imperial Aluminium Company Limited · Birmingham

Circle **No 53** on reply card for further details

RESIN IMPREGNATION

of wire-wound components under vacuum

N.G.N. new 'Resin-impregnating Plant' not only ensures better and far more thorough impregnation of all types of wire coils—its faster cycle of operation, coupled with carefully designed thermostatic control of vessels and pipework, plus full bore resin transfer valve, all combine to speed output while reducing costs.

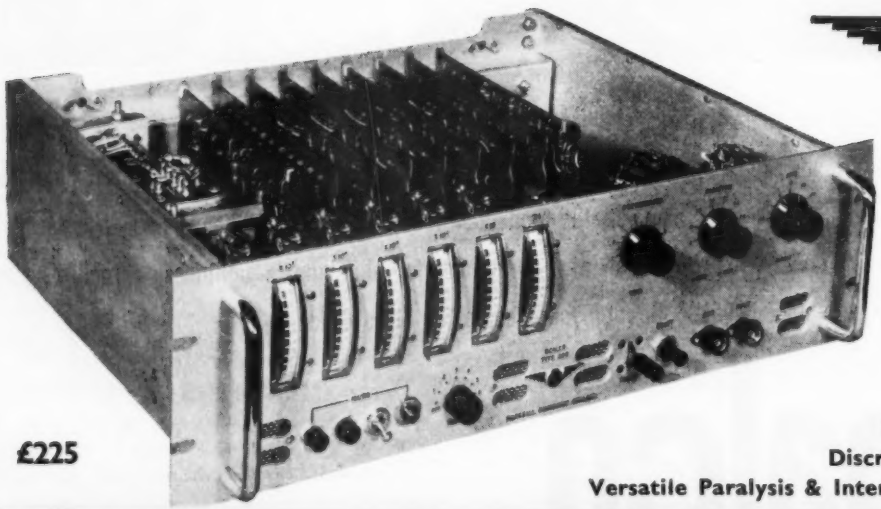
Work chamber is evacuated to 1 micron Hg. to degas and dehydrate components which are then impregnated under a pressure of 80 lbs. p.s.i.

Surplus impregnant is completely recovered. Absolute reliability, both as regards thoroughness of impregnation and regular output is assured.

Enquiries for special plant to user requirements are especially welcome.

N.G.N. ELECTRICAL LIMITED
AVENUE PARADE, ACCRINGTON, LANCS. Tel: Accrington 35611-2

MARSHALL



1 Mc/s SCALER

Type 200

£225

Transistorised
Resolving Time 1 μS
Discriminator Ratio 20: 1
Versatile Paralysis & Internal Timing Circuits

Enquiries to Sales Department

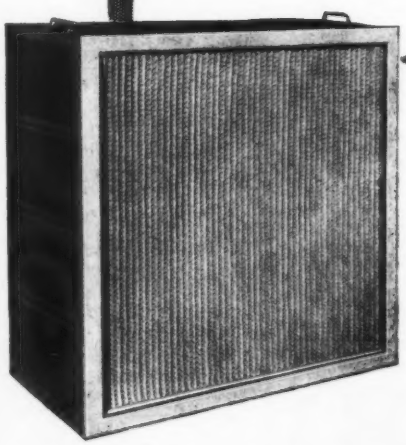
MARSHALL OF CAMBRIDGE ELECTRONICS LIMITED
THE AIRPORT · CAMBRIDGE · ENGLAND

A speck of dust 1/10,000

of a millimetre in size has only

one chance in 10,000 of getting

past this Vokes 'Absolute' Filter



Other filters in Vokes 'Absolute' range include the standard type (guaranteed 99·95% efficient against sub-micronic particles) and high humidity and acid resistant types (guaranteed 99·99% efficient against sub-micronic particles).

...and that's guaranteed

Vokes 'Absolute' high temperature filters were developed for critical applications involving risk of fire, or temperatures up to 1000°F. They have proved particularly valuable in the filtration systems of nuclear power stations where a breakdown caused by an outbreak of fire might release dangerous toxic particles to atmosphere.

These filters have a guaranteed *minimum* efficiency of 99·99% against particles in the 0·1 to 0·5 micron range: therefore impurities in the air ranging in size from a ten thousandth of a millimetre to a two thousandth of a millimetre have only one chance in ten thousand of passing through the high temperature 'Absolute' all glass paper filter medium.

In addition Vokes *guarantee* the accuracy of these figures. As with all Vokes 'Absolute' filters, every high temperature type is tested in accordance with BSS 2831 on a methylene blue test rig and rejected if its efficiency is below the required standard.

You are invited to write for a booklet covering the range of Vokes special purpose air filters and containing details of Vokes unique testing methods.

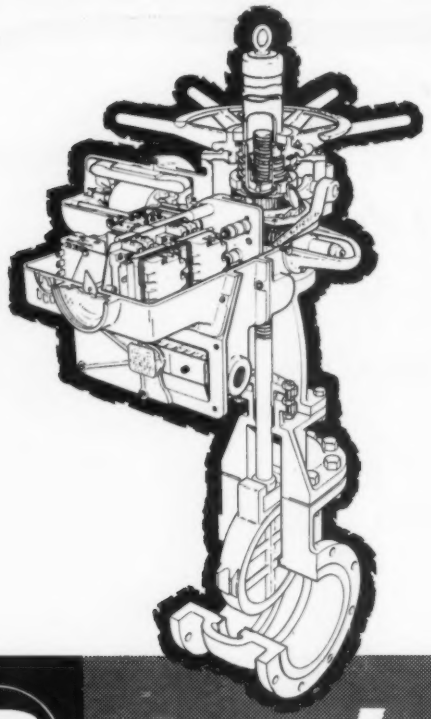
VOKES leave ***absolutely*** nothing to chance

VOKES LIMITED · HENLEY PARK · GUILDFORD · SURREY

Telephone: Guildford 62861 (6 lines) Telegrams: Vokesacess, Guildford, Telex. Telex: 8-535 Vokesacess, Gfd. *Represented throughout the world*

V.550

Circle No 57 on reply card for further details



Rotork

international valve control

Rotork, for a long time the only Company in Britain specializing in valve motorisation, is now the only British Company with an *international* approach to valve control requirements.

THE ACTUATORS.
The Rotork 'A' range of actuators in standard form meets most requirements but can also be supplied to comply with any industrial or national specification. The range covers the power requirements of every type or size of valve.

THE CONTROL SYSTEM.
The electrical equipment and circuitry provide a flexible, versatile system which meets every type of control requirement, including local or remote pushbutton, automatic operation from data, sequence control and interlocking with other actuators or associated equipment etc.

MANUFACTURE, SALES & SERVICE.
Highly competitive prices on a world wide scale are assured by manufacturing and sales facilities in West Germany, France and Italy to augment U.K. production, as well as offices or agents in Holland, Switzerland, Australia, Canada, South Africa and the Arabian Gulf.

EXPERIENCE & REPUTATION.
Name any big company in a valve-using industry and it is almost certain that you have named a Rotork customer.

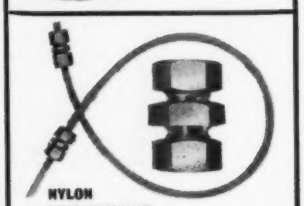
Please write for our booklet entitled "ROTORK VALVE CONTROL".

ROTORK ENGINEERING CO. LTD. of BATH, ENGLAND. Tel: 64558

Circle No 58 on reply card for further details

Simple! Secure! Speedy!

SIMPLIFIX COUPLINGS


NYLON TUBE FITTINGS
The wide range of nylon tube couplings uses standard bodies. Nylon tube can be supplied in various colours.

Simplifix compression couplings are the easiest, fastest, most practical way to connect copper or nylon tube . . . designed to make perfect joints at the turn of a spanner without the pipe twisting. Simplifix couplings are made in a full range of standard sizes. Also, non-standard fittings can be quickly produced to your specification. Illustrated catalogue and technical advice gladly provided on request.

SIMPLIFIX

SIMPLIFIX COUPLINGS LIMITED · HARGRAVE ROAD · MAIDENHEAD · BERKS.
TEL: MAIDENHEAD 5100 · A member of the ALENCO Group of Companies

SERVICE DE RENSEIGNEMENTS POUR NOS LECTEURS

Il est souvent difficile au client publicitaire d'indiquer dans un espace restreint tous les détails de ses produits. Dans le cas où vous désireriez de plus amples renseignements à ce sujet, veuillez pointer le numéro approprié sur la carte ci-contre et envoyer cette dernière à NUCLEAR POWER.

AUSKUNFTSDIENST FÜR LESER

Es ist oft schwierig für Inserenten alle technischen Einzelheiten über ihre Produkte in einem begrenzten Platz zu bringen. Sollten Sie noch weitere Auskünfte wünschen, streichen Sie einfach die bestimmten Nummern auf der nebenstehenden Karte an, und senden Sie sie an NUCLEAR POWER.

SERVIZIO D'INFORMAZIONI PER I NOSTRI LETTORI

E' talvolta difficile all'inserzionista di indicare in uno spazio ristretto tutti i particolari dei suoi prodotti. Qualora desideraste ricevere più ampie informazioni a questo riguardo, favorite segnare il numero appropriato sul cartellino qui accanto ed inviare quest'ultimo a NUCLEAR POWER.

SERVICIO DE INFORMACIÓN PARA EL LECTOR

Se hace a menudo difícil para los anunciantes dar en un espacio limitado todos los detalles técnicos sobre sus productos. Si desea ulterior información, marque los números apropiados en la tarjeta opuesta y mándela a NUCLEAR POWER.

Информация для читателей

Часто бывает трудно рекламирующим лицам давать все технические подробности своей продукции в рекламе. Если Вам понадобятся добавочные сведения, то просто отметьте соответствующие номера на карточке на противоположной стороне и отправьте в NUCLEAR POWER.

读者咨询服务

在广告上以有限的地方来解释一些专门技术及它们的效果的确是有受限制的困难。若读者欲查知一些详细的情形就请对贵的表格取一张下来将阁下有疑问的项目问笔勾一即寄给子能工社总部可。

読者サービス

広告紙面の関係上製品の技術的細目は掲載しきれません ので詳しくは葉書のコードの適当なナンバーに印をつけて原本が発送して下さればお答へします。

READER INFORMATION SERVICE

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Ind. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

262	264	266	268	270	272	274	276	278
263	265	267	269	271	273	275	277	279

Research and Development

280	282	284	286	288	290	292	294	296
281	283	285	287	289	291	293	295	297

Nuclear Power — REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

MAY 1961

If you would like further information about any advertisement or editorial item, simply circle the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

POSITION HELD

NAME OF BUSINESS

ADDRESS

COUNTRY

NATURE OF BUSINESS

READER INFORMATION SERVICE

Advertisements

1 24 47 70 93 116 139 162 185
2 25 48 71 94 117 140 163 186
3 26 49 72 95 118 141 164 187
4 27 50 73 96 119 142 165 188
5 28 51 74 97 120 143 166 189
6 29 52 75 98 121 144 167 190
7 30 53 76 99 122 145 168 191
8 31 54 77 100 123 146 169 192
9 32 55 78 101 124 147 170 193
10 33 56 79 102 125 148 171 194
11 34 57 80 103 126 149 172 195
12 35 58 81 104 127 150 173 196
13 36 59 82 105 128 151 174 197
14 37 60 83 106 129 152 175 198
15 38 61 84 107 130 153 176 199
16 39 62 85 108 131 154 177 200
17 40 63 86 109 132 155 178 201
18 41 64 87 110 133 156 179 202
19 42 65 88 111 134 157 180 203
20 43 66 89 112 135 158 181 204
21 44 67 90 113 136 159 182 205
22 45 68 91 114 137 160 183 206
23 46 69 92 115 138 161 184 207

New Products and Ind. Literature

208 214 220 226 232 238 244 250 256
209 215 221 227 233 239 245 251 257
210 216 222 228 234 240 246 252 258
211 217 223 229 235 241 247 253 259
212 218 224 230 236 242 248 254 260
213 219 225 231 237 243 249 255 261

Books

262 264 266 268 270 272 274 276 278
263 265 267 269 271 273 275 277 279

Research and Development

280 282 284 286 288 290 292 294 296
281 283 285 287 289 291 293 295 297

Nuclear Power — REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

MAY 1961

If you would like further information about any advertisement or editorial item, simply circle the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

POSITION HELD

NAME OF BUSINESS

ADDRESS

COUNTRY

NATURE OF BUSINESS

READER INFORMATION SERVICE

Advertisements

1 24 47 70 93 116 139 162 185
2 25 48 71 94 117 140 163 186
3 26 49 72 95 118 141 164 187
4 27 50 73 96 119 142 165 188
5 28 51 74 97 120 143 166 189
6 29 52 75 98 121 144 167 190
7 30 53 76 99 122 145 168 191
8 31 54 77 100 123 146 169 192
9 32 55 78 101 124 147 170 193
10 33 56 79 102 125 148 171 194
11 34 57 80 103 126 149 172 195
12 35 58 81 104 127 150 173 196
13 36 59 82 105 128 151 174 197
14 37 60 83 106 129 152 175 198
15 38 61 84 107 130 153 176 199
16 39 62 85 108 131 154 177 200
17 40 63 86 109 132 155 178 201
18 41 64 87 110 133 156 179 202
19 42 65 88 111 134 157 180 203
20 43 66 89 112 135 158 181 204
21 44 67 90 113 136 159 182 205
22 45 68 91 114 137 160 183 206
23 46 69 92 115 138 161 184 207

New Products and Ind. Literature

208 214 220 226 232 238 244 250 256
209 215 221 227 233 239 245 251 257
210 216 222 228 234 240 246 252 258
211 217 223 229 235 241 247 253 259
212 218 224 230 236 242 248 254 260
213 219 225 231 237 243 249 255 261

Books

262 264 266 268 270 272 274 276 278
263 265 267 269 271 273 275 277 279

Research and Development

280 282 284 286 288 290 292 294 296
281 283 285 287 289 291 293 295 297

Nuclear Power — REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

MAY 1961

If you would like further information about any advertisement or editorial item, simply circle the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

POSITION HELD

NAME OF BUSINESS

ADDRESS

COUNTRY

NATURE OF BUSINESS

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

NUCLEAR POWER
Rowse Muir Publications Ltd,
The Rowse Muir Building,
77–79 Charlotte Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

NUCLEAR POWER
Rowse Muir Publications Ltd,
The Rowse Muir Building,
77–79 Charlotte Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

NUCLEAR POWER
Rowse Muir Publications Ltd,
The Rowse Muir Building,
77–79 Charlotte Street,
London, W1
England

STAINLESS STEEL FABRICATIONS

by the specialists

- ★ **Pressure Vessels all classes**
- ★ **Vessels for storage and transport**
- ★ **Condensers and Heat-Exchangers**
- ★ **Pipework and Pipefittings**
- ★ **Laboratory Equipment and Holloware**
- ★ **Ducting and other stainless steel sheet metal work**
- ★ **X-ray weld inspection**

A 200 gallon stainless steel reaction vessel with coil jacket suitable for high pressure steam

As specialists in the manufacture of stainless steel products for 30 years, we have exceptional knowledge of the material. Our staff are skilled in the design of equipment in this metal and our work people in its manipulation. You can therefore place your requirements in no better hands.

THE TAYLOR RUSTLESS FITTINGS Co. Ltd.

Head Office: Ring Rd., Lower Wortley, Leeds, 12. *Telephone:* Leeds 638711 PBX
London Office: 14 Great Peter Street, London, S.W.1. *Telephone:* Abbey 1575

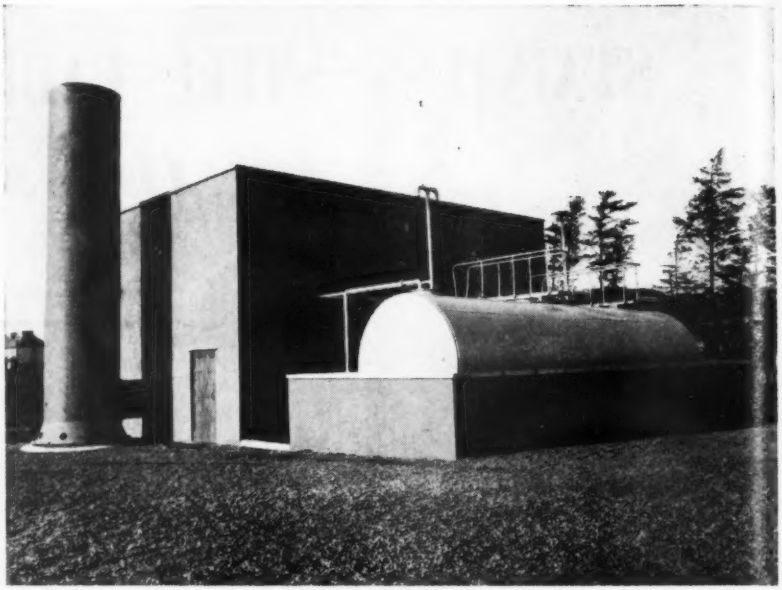
Circle No 59 on reply card for further details

Circle **No 60** on reply card for further details

WHAT IS IT?

The spin of a Bristol telephone dial at the South Western Electricity Board's control centre *automatically* whirls a generator into life one hundred miles away in Princetown on Dartmoor. Within minutes Britain's only *unmanned* 'pocket' power station steps up to full power output—sufficient for the needs of a town of ten thousand people. Illustrated here, this new power station has a 3,000 kilowatt generator driven by a 4,250 h.p. turbine—and it requires only four routine visits a year; *an overhaul once every ten years!*

But if human eyes are not there to guard over costly machinery, Walter Kidde *is*! Constantly, automatically, Kidde fire protection equipment is ready for every emergency—sure protection when so much is at stake.



Those who have the experience to judge the best buy Kidde

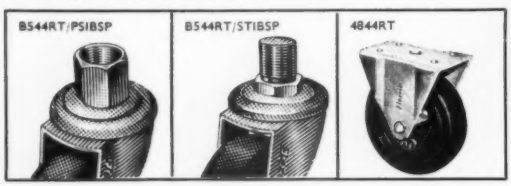
THE WALTER KIDDE COMPANY LTD., Northolt, Middx. Telephone: Viking 6611

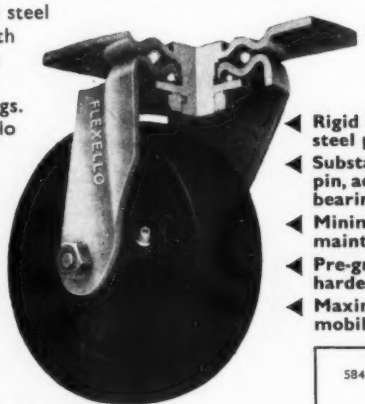
ONE MAN TO MOVE... WENT

Yes, one man is all you need. Once you fit Flexello double ball-bearing all steel castors to your trolleys and other equipment, one man can move with ease what it took four to drag before. The stout kingpin of Series 44 is adjustable for wear. Flexello Series 44 Castors give extra mobility, strength and economy. They are available in a variety of wheels and tubular fittings. Zinc plated rust-proof finished. Fit your equipment with Series 44 Flexello Constant Quality Castors and get things moving.

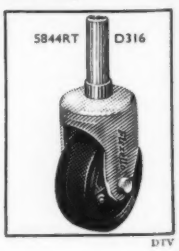
544RT/D316

B544RT/PSIBSP Pipe socket fittings supplied with gas thread for outside fitting.
B544RT/STIBSP Threaded stem and BS male pipe fitting.





- **Rigid embossed steel pressings.**
- **Substantial king-pin, adjustable for bearing protection.**
- **Minimum of maintenance.**
- **Pre-greased hardened bearings.**
- **Maximum ease of mobility.**



FIT YOUR EQUIPMENT WITH SERIES 44

Flexello CONSTANT QUALITY CASTORS

Write for comprehensive fully illustrated catalogue to: FLEXELLO CASTORS & WHEELS LTD., SLOUGH, BUCKS.

DTV

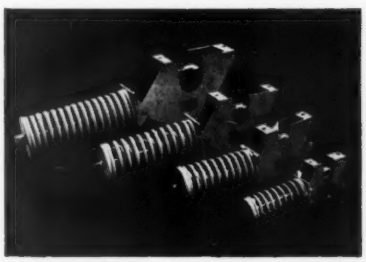
Circle **No 61** on reply card for further details

"I'm a belt and braces man, myself"

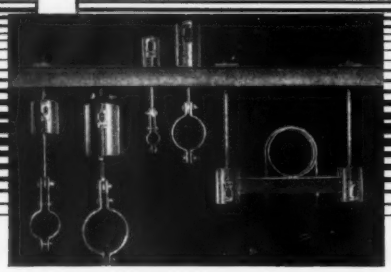
"Because I wear both, my mates reckon I'm a bit of a pessimist! But when it's a matter of essential support I'd rather be safe than sorry. Likewise, I've rigged enough to know that pipework suspended from Gensprings is never going to give any trouble. They use Gensprings on the big nuclear stuff!

This small one just above my head is an M2 Constant Support Hanger. There's a range of sizes to deal with loads from 315 lb. to 97,800 lb. Maximum deviation—if you need it this exact—can now be guaranteed at not more than 2%.

Then there are the Variable Supports for jobs less critical than those needing "Constants", and then again there are Sway Braces for damping out shock and vibration. I'm beginning to sound like the catalogues that Vokes Genspring will be glad to send you!"



Vokes Genspring 'M' Range Constant Support Hangers for supporting pipework and other high temperature equipment such as heat exchangers, furnace walls, condensers, etc. The constant supporting effort is equal to the weight of the pipework irrespective of thermal movements.



The Vokes Genspring range of Variable Supports covers travel ranges of 1½", 3" and 6", and there are 16 sizes in each range, covering loads from 58 lb. to 13,790 lb.

Vokes Genspring Non-Resonant Sway Braces can control all pipework subject to vibration and normal thermal expansion. Eight spring sizes cover loads from 39 lb. to 1,500 lb.

VOKES GENSPRING HAVE REALLY GOT THE 'HANG' OF PIPEWORK!

Vokes Genspring SUSPENSION SYSTEMS

VOKES GENSPRING LTD · HENLEY PARK · GUILDFORD · SURREY

Telephone: Guildford 62861 Telegrams: Vokesacess, Guildford, Telex Telex: 8-535, Vokesacess, Gfd.

A member of the VOKES GROUP with world-wide representation

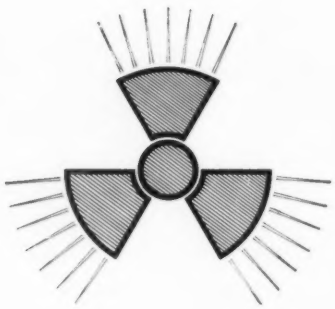
VG.40

Circle **No 63** on reply card for further details

LEAD

ALL FORMS OF RADIATION PROTECTION

- CASTLES
- CONTAINERS
- COCKS
- BRICKS
- SHOT

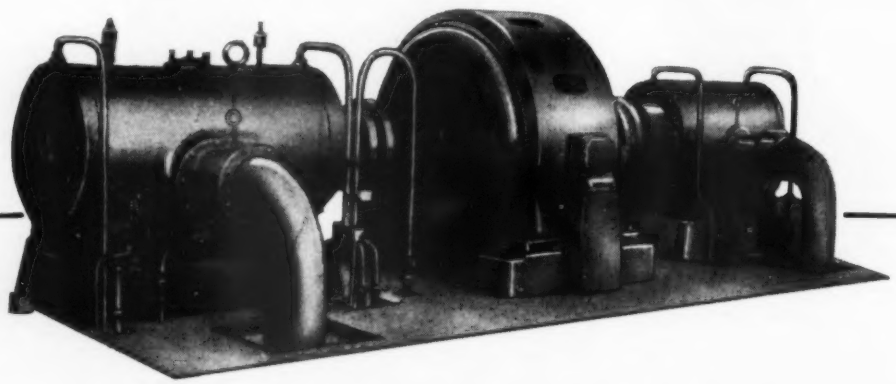


- SHUTTERS
- DOORS
- POWDER
- TUBES
- SLABS

Licensed by the Commissariat à l'Energie Atomique, Paris

FONDERIE DE GENTILLY

56, rue Raymond-Lefèvre GENTILLY (Seine) Phone: ALE, 18-55



HOLLAND-S. L. M.

ROTARY COMPRESSORS AND VACUUM PUMPS

SUPPLIED FOR: **HARWELL, WINFRITH, BERKELEY**

The B. A. Holland Engineering Co. Ltd.

LINDO LODGE, STANLEY AVENUE, CHESHAM, BUCKS.

Telephone: Chesham 8406/8 **Telegrams: Picturable Chesham** **Works: SLOUGH, BUCKS**

off the cuff . . .

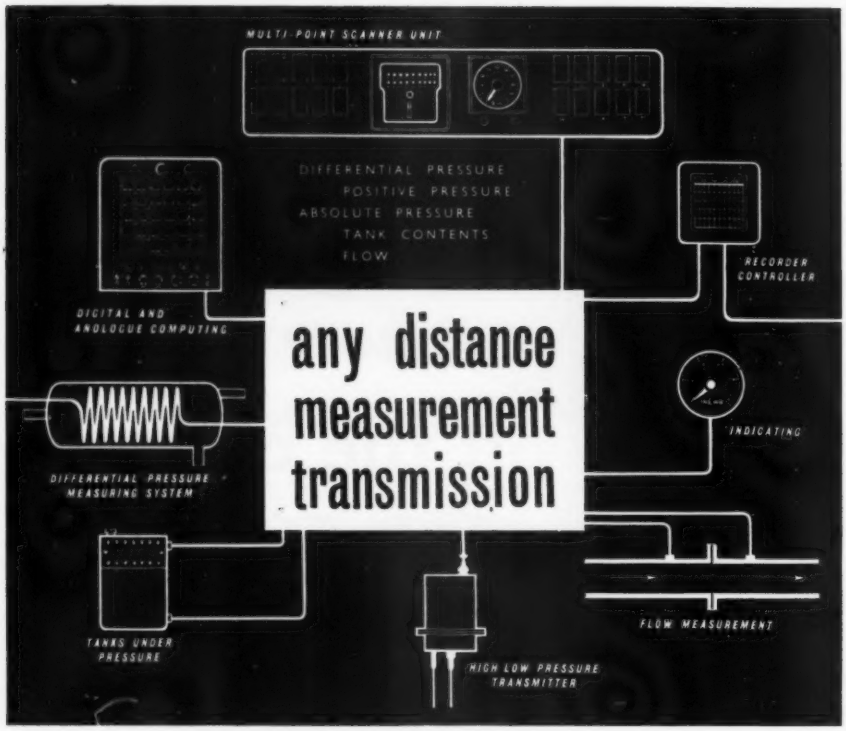
The New BURGESS V-4

- No larger than the average cuff-link
- New mechanism has mechanical life of at least 10 million operations
- Three types of solder terminals available
- Comprehensive range of auxiliary actuators

BURGESS MICRO SWITCHES

BURGESS PRODUCTS COMPANY LTD, MICRO SWITCH DIVISION, DUKES WAY, TEAM VALLEY, GATESHEAD 11
Telephone: Low Fell 75322. Telex: 53-229 London Office: 127 Victoria Street, SW1. Telephone: TATe Gallery 0251 Telex: 25601

Circle **No 66** on reply card for further details



FEATURES OF THE 'REDIFF' PRESSURE GAUGE

★ Measurements from 0 to 1 inch of water gauge full scale deflection.

★ High Static Pressures gradually or instantaneously.

★ Instantaneous High Static Overload.

★ Usable with liquids/gases having radio-active constituents.

★ Models made of MONEL available.

★ Capable of withstanding sudden pressures up to 4,000 p.s.i. and temperature up to 250°c.

★ Electrical Supply: 100-200-220-240, 50 or 60 c/s.

Ask for details of the 'Rediff' Instrument from:

APPLEBY & IRELAND LTD

Basingstoke : Hampshire : England. Tel: Basingstoke 2510/3 Telex: 8546

---

industries atomiques

The international review for the peaceful uses of nuclear energy

A RENE KISTER PUBLICATION

Annual Subscription (12 numbers per year):
French N.F. 50; Belgian francs 640; Swiss francs 50; German marks 50; U.S. dollars 12·5; Pounds sterling 4.0.0

Free Copy: Fill in the coupon herewith and mail it today. You shall receive a **Free Copy** and prospectus.

INDUSTRIES ATOMIQUES

is the only international technical and industrial review printed in French, which specialises entirely in nuclear and related subjects.

INDUSTRIES ATOMIQUES is read by industrialists, engineers, technicians and chemists, heads of technical firms and by all those engaged in the world of science. In short, it is intended expressly for all specialists interested in research and in its practical realisation.

In view of its international character, **INDUSTRIES ATOMIQUES** is read and appreciated in countries all over the world.

Up to date, more than 350 authors, all specialists, have honoured this review with their collaboration, and have contributed **previously unpublished** articles of high scientific value, abundantly illustrated.

INDUSTRIES ATOMIQUES is a source of precise documentation, constantly being brought up to date. The international information and the list of suppliers to the atomic industries printed in its pages will be found invaluable.

Industries Atomiques Subscription form

Subscriptions can be paid in the currency of the country at any European post office.

We desire _____ **annual subscriptions, starting from** _____, **to be sent to (surname, Christian names, or firm's name, and address)** _____

_____

Method of payment _____ **Date and signature:** _____

(This form should be returned in a stamped and addressed envelope to NUCLEAR POWER, 77-79 Charlotte Street, London, W1.)

In which BLM serves

British Lead Mills supplied lead in the form of slabs for nuclear shielding and bars for ballasting in Britain's first atomic powered submarine "Dreadnought". Both specifications called for exceptionally high purity and extremely exact methods of manufacture. The slabs for nuclear shielding were tested by the latest ultrasonic techniques to exclude the possibility of inclusions and laminations. The ballast bars were pressure moulded to ensure uniform weight and density. British Lead Mills are staffed and equipped to handle demands for lead and lead alloys to rigid specifications for any purpose. Why not send us your next enquiry?

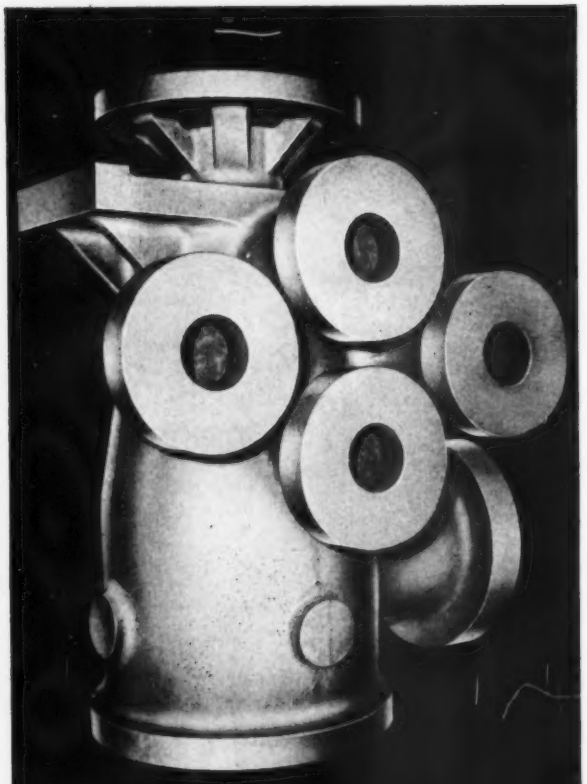
A typical lead brick for nuclear shielding developed and manufactured by British Lead Mills

British Lead Mills A MEMBER OF THE FIRTH CLEVELAND GROUP FC

BRITISH LEAD MILLS LIMITED · 7 CLEVELAND ROW · LONDON S.W.1 · Telephone: WHitehall 5772

CRC 32

Circle No 69 on reply card for further details



ATLAS

STEEL CASTINGS
For Internal Pressure Work

Turbine Casings, Steam Chests, Valves, etc., in carbon and alloy steels up to 15 tons weight and to any specification.
ON ADMIRALTY, WAR OFFICE, LLOYD'S and other LISTS.

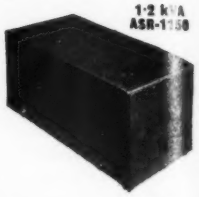
THE ATLAS STEEL FOUNDRY & ENGINEERING CO. LTD.

Atlas Steel Works, Armadale, West Lothian, Scotland
Telegrams: "Atlas Armadale, West Lothian"
Telephone: 323 Armadale

Circle No 70 on reply card for further details

Claude Lyons

COMPACT SERIES ASR & ATC
Ingenious step principle. Small, light, inexpensive. Designed to provide adequate stabilisation for many applications, without distortion. 600 VA to 2·4 kVA. Normal or tropical finish.

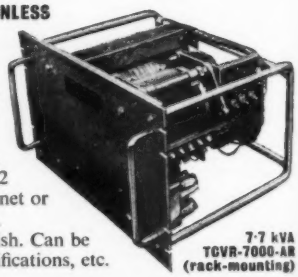


AC AUTOMATIC

PRECISION ELECTRONIC SERIES BAVR
Extremely rapid response. Very high accuracy of ± 0·15%. Models for ratings of 200, 500, & 1000 VA. Normal or tropical finish.

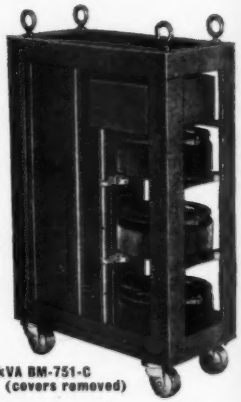
VOLTAGE REGULATORS

HIGH-SPEED DISTORTIONLESS SERIES TCVR
For precision equipment, computers, etc. Accuracy ±0·5%. Very high correction rate of 40 volts/sec. Large range, 2·2 to 12·7 kVA single-phase, 6·5 to 38·2 kVA three-phase. Cabinet or rack-mounting models. Normal or tropical finish. Can be made to Services' specifications, etc.



AND STABILISERS

DISTORTIONLESS SERIES BM & BMVR
Wide industrial and laboratory applications. Accuracy ± 0·5%. Very large range, 1·8 to 31·2 kVA single-phase, 6·5 to 94 kVA three-phase. Many models for rack-mounting. Normal or tropical finish. Can be made to Services' specifications, etc.



200 VA TO 94 KVA

- Operation of all types independent of wide variations in frequency.
- Special models manufactured to customers' quantity requirements.

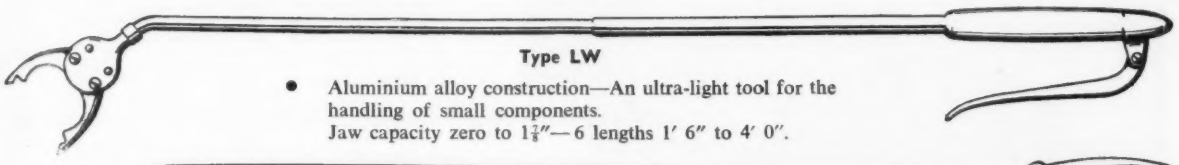
Write for complete information.

Claude Lyons Ltd.
STABILISER DIVISION
VALLEY WORKS · HODDESDON · HERTS
Tel: HODDESDON 4541-6

CL60/3A

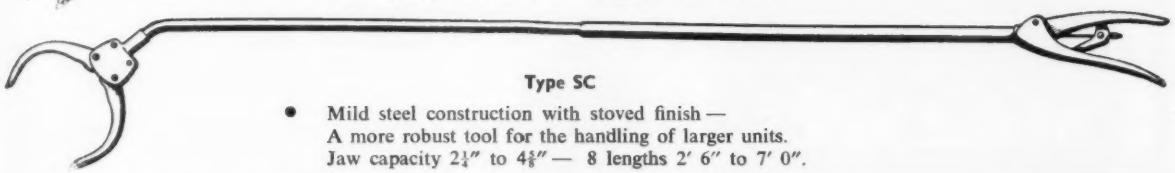
Circle **No 71** on reply card for further details

REMOTE HANDLING TOOLS



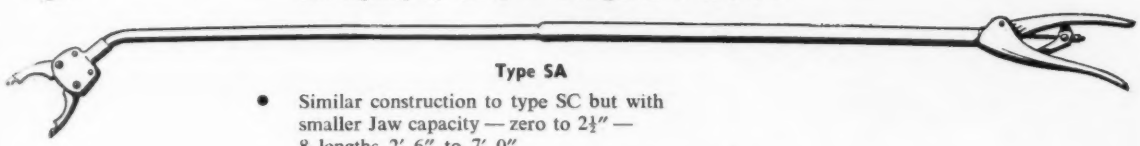
Type LW

- Aluminium alloy construction—An ultra-light tool for the handling of small components.
  Jaw capacity zero to $1\frac{7}{8}$″—6 lengths 1′ 6″ to 4′ 0″.



Type SC

- Mild steel construction with stoved finish — A more robust tool for the handling of larger units.
  Jaw capacity $2\frac{1}{4}$″ to $4\frac{5}{8}$″ — 8 lengths 2′ 6″ to 7′ 0″.



Type SA

- Similar construction to type SC but with smaller Jaw capacity — zero to $2\frac{1}{2}$″ — 8 lengths 2′ 6″ to 7′ 0″.
- Types SA and SC manufactured in other lengths to order.

Write for details of our range — or let us know your special requirements

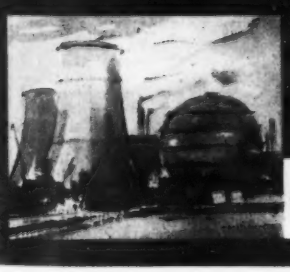
CARTER & VINER · PRESS TOOL ENGINEERS

COODEN SEA ROAD · BEXHILL · SUSSEX · TELEPHONE: COODEN 143

Export Enquiries to:— C. Phillips Jones & Co Ltd · Dorchester-on-Thames · Oxford

HEAT EXCHANGERS

We have vast experience in the design and construction of heat exchangers in light alloy and stainless steel. We shall be glad to help you in this field too.



Delaney Gallay

THERMAL INSULATION BLANKETS

have been tested up to 1250°C

—but quite apart from their ability to withstand very high temperatures successfully, Delaney Gallay blankets have another big advantage for the nuclear field.

Completely encased in stainless steel, they require no maintenance and are not easily damaged.

Delaney Galley Thermal Insulation Blankets can be made to fit both simple and complex shapes. The stainless steel sheathing is dimpled for maximum rigidity, and can be completely sealed against the ingress of liquids if necessary.

They are designed for easy fitting and removal, and can be supplied with apertures to accommodate controls.

If you would like further information, please contact us. We shall be happy to supply it.

Delaney Gallay LTD *Experts in Heat Exchange & Heat Insulation for over 40 years*

Vulcan Works, Edgware Road, London, N.W.2. Tel: GLAdstone 2201

Circle **No 73** on reply card for further details

new advancements in NUCLEONICS from U. S. A.

Frazar & Hansen Ltd., internationally known since 1834, presents many leading U.S.A. manufactured nuclear instruments and components, including monitors and detectors, radio-chemical analysis equipment, nuclear medical scanners, educational teaching aids and radiation shielding and protective equipment. **Write for information.**

New Gamma Irradiators

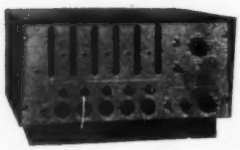
Model GR-6 is loaded with Cs-137 to provide a flux of 5000 R/hr at an external dosage of less than 2 mr/hr at 1 foot from surface. Loading with fluxes to 12,000 R/hr available. Model GR-9, loaded with Co-60, provides flux level of 100,000 R/hr at a fraction of the external dosage level of less than 5 mr/hr at 1 foot from the surface. May be loaded for fluxes to 1,000,000 R/hr and remain within the stated external dosage level.

U.S. NUCLEAR CORP.

Fast Neutron Counter

The Model FN-1A Fast Neutron Counter—Scintillation Type—has three ranges, 0–50, 0–500 and 0–5000 neutrons/cm²/sec. It features an insensitivity to gamma radiation to 1 R/HR. Using a 2 in. diameter by $\frac{1}{4}$ in. thick ZnS plastic crystal, the instrument is splash proof, shock resistant and capable of operating up to plus 130 degrees F. High voltage power supply, amplifier-trigger and meter accessories are supplied on transistorized, plug-in cards.

EBERLINE INSTRUMENT CORP.



Computer Scaler

Model QS-6 READ-O-MATIC. An all-electronic computer scaler with a count storage and display channel and an electronic timer channel. It is a true events-per-unit-time computer for work involving medium and long time base intervals encountered in nuclear, electronic, industrial and other applications in measurement and control. Computed counting rate is displayed with decimal point properly placed.

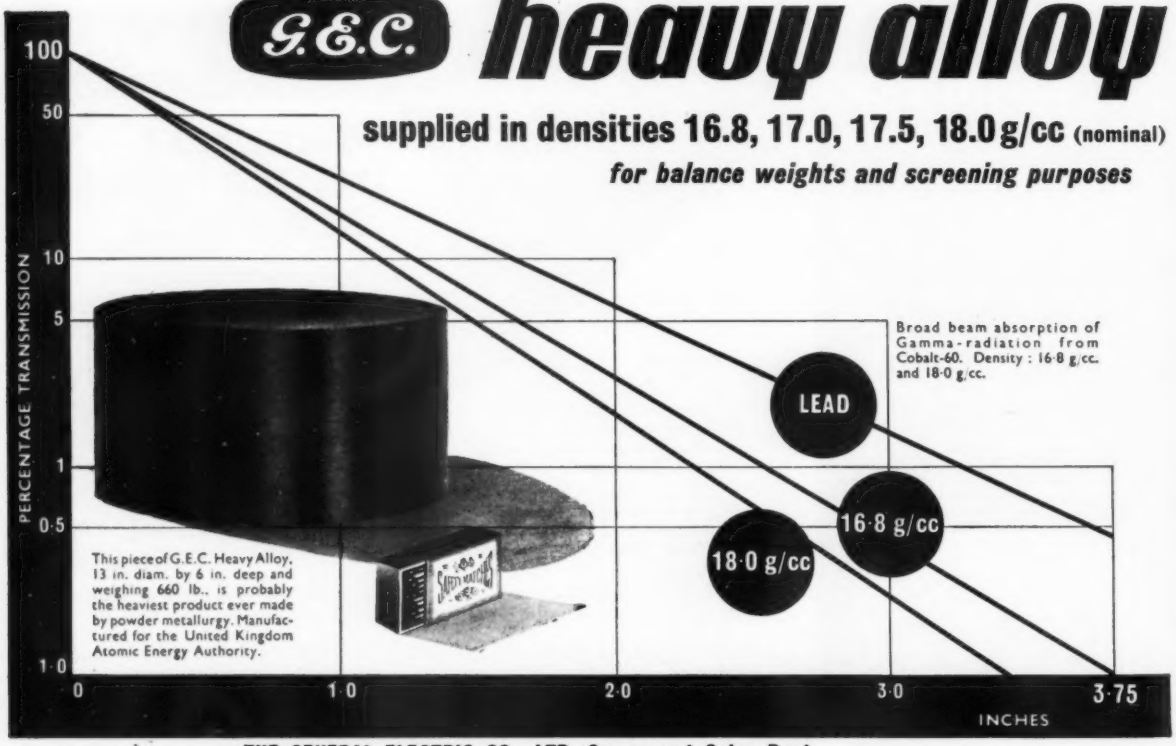
ATOMATION, INC.

FRAZAR & HANSEN Ltd., 301 Clay Street, San Francisco, Calif., U.S.A.

G.E.C. heavy alloy

supplied in densities 16.8, 17.0, 17.5, 18.0 g/cc (nominal)

for balance weights and screening purposes



THE GENERAL ELECTRIC CO., LTD. Component Sales Dept.
Osram Division, East Lane, Wembley, Middlesex. Tel: ARNold 4321

Circle No 75 on reply card for further details

When Cooling's a Problem...

Call in **PREMIER** for expert advice

Undoubtedly the answer to all air and hydrogen cooling problems is PREMIER. PREMIER closed circuit coolers are among the most highly efficient and economical in the world—installed in such important power stations as Meaford, Poole, Uskmouth, Hams Hall "C", Darlington, Bold "B", Stockport and Johannesburg; and hydrogen coolers and heat exchangers in hand for Hunterston Atomic Power Station and many other important overseas works and power stations, large and small. PREMIER design and erect the plants, guarantee the performance and give a 100 per cent. after-sales service. Certainly, the scientifically engineered construction and high efficiency and economy of PREMIER closed circuit air coolers is the reason why they are acclaimed by engineers everywhere.

If you have an air or hydrogen cooling problem, write to us—our advice is yours for the asking.

WE *do the designing ourselves*
WE *erect the plants ourselves*
WE *manufacture our own plants*
WE *guarantee the performance*

PREMIER COOLING TOWERS

THE PREMIER COOLER & ENGINEERING CO. LTD.
SHALFORD · NR. GUILDFORD · SURREY

Circle No 76 on reply card for further details

TIME CLOCK CARDS

TO FIT EVERY TYPE OF MACHINE
EXACTLY TO YOUR REQUIREMENTS

Our Time Cards are manufactured with extreme care and we guarantee them to work perfectly in All Clocks.

PRECISION PRINTING

For SPIRIT DUPLICATORS *and* MARGINAL

PUNCHED CARDS

Harlow *for* Cards

We can quote for any type of Card by return: send us your samples today.

HARLOW

104-110 FREDERICK STREET
SOUTH SHIELDS

Telephone: **South Shields 4286 (3 lines),** *for our Representative to call.*

Circle No 77 on reply card for further details

Stockholders of

STAINLESS STEEL

SHEETS · BARS · PLATES
STRIPS & BLANKS

PROFILE CUTTING &
SHEET POLISHING

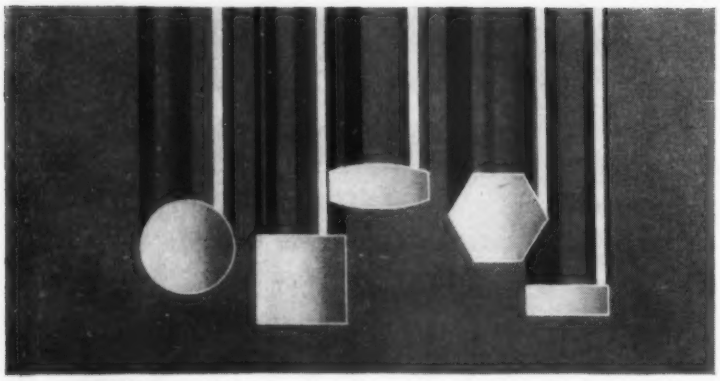
COX AND DANKS
LIMITED

PROFILE CUTTING
TO ANY SHAPE

SCAPA HOUSE · PARK ROYAL RD.
LONDON N.W.10

Tel: Elgar 5811 Telex 25239

Circle **No 78** on reply card for further details



CARLISLE

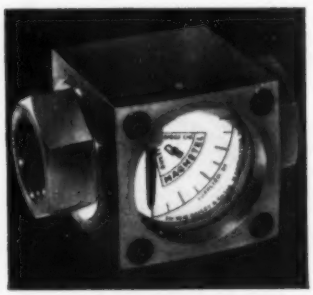
THE KEY NAME TO BETTER STEELS

— and certainly the key to your requirements — for Carlisles have almost 40 years experience of supplying Stainless Steels wherever quality is the key word.

C. G. CARLISLE & Co., LIMITED

IONA STEEL WORKS, PENISTONE ROAD, SHEFFIELD *Telephone* **348791**

Circle **No 79** on reply card for further details



New flow indicator for opaque liquids

The MAGNETEL

The Magnetel is a flap type indicator—with a vital difference. A magnet set into the flap controls the indicator pointer, eliminating the need for springs and mechanical linkages. The Magnetel is a sensitive instrument suitable for liquids of almost any viscosity.

A special model is available for use with liquids containing ferrous particles, and the flap can be arranged to permit flow in either direction. All parts are accessible for maintenance without disconnecting the pipe line.

Available in sizes from ¾ in. to 2 in., the Magnetel supplements Bailey's already famous Telicator range of Rotary Flow Indicators.

Please write for detailed descriptive brochures.

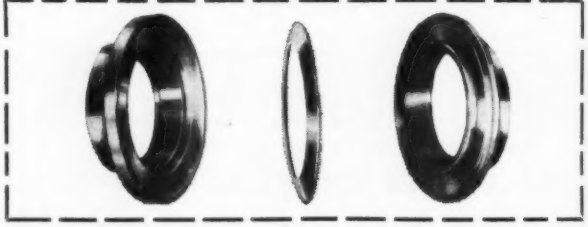
Bailey's REGD SIR W. H. BAILEY & COMPANY LIMITED

HEAD OFFICE & EXPORT SALES: Albion Works, Patricroft, Manchester. Tel: Eccles 3487 (4 lines)
LONDON & SOUTHERN AREA SALES: Selinas Lane, Dagenham, Essex. Tel: Dominion 2277 (3 lines)

PRESSURE REGULATORS · SLUICE VALVES · TEST PUMPS · TURNSTILES

TGA TRM IA

Circle **No 80** on reply card for further details

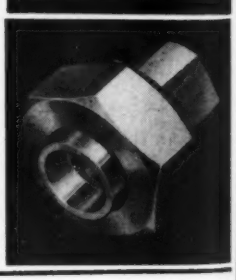


KING *Conoseal* HEAVY DUTY PIPE COUPLINGS

ZERO LEAKAGE

in conditions of extreme temperature and pressure

Robust, dependable, corrosion resistant Conoseal Couplings provide the perfect joint on heat transfer systems, pressure and vacuum lines and cryogenic systems. Consisting of two cone flanges, a frustro conical gasket and a V-Band Clamp; the Conoseal Coupling is easily installed and assembled.

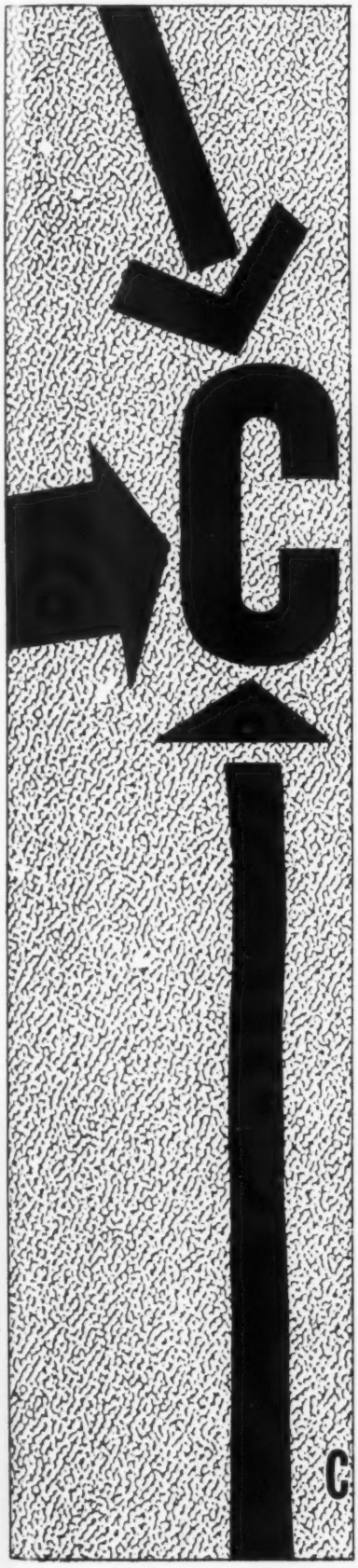


Above right
Heavy Duty Conoseal Coupling with 3 segment clamp

Right
Conoseal Union Fittings for joining all types of small diameter tubing.

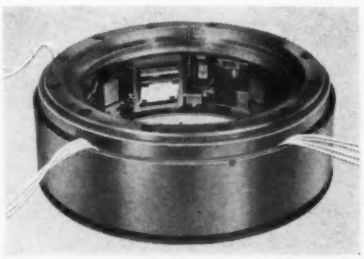
KING AIRCRAFT CORPORATION (KAC) LTD.,

Cameron Street, Hillington, Glasgow S.W.2
Tel: Halfway 4571



The PATTERN of PROGRESS POINTS to COLVERN

The search for greater accuracy is never ending and COLVERN have for 30 years led the way in the development of Precision Potentiometric Devices. Illustrated is the NOSE MEASURING UNIT incorporated in the Re-fuelling Machine manufactured by John Brown (S.E.N.D.) Ltd. for the U.K. Atomic Energy Authority at Windscale. This unit developed and produced by Colvern comprises the sensing devices for fine positioning of the machine. Colvern Precision Potentiometers are naturally fitted in the associated electronic equipment. COLVERN SAFETY SWITCHES are used to indicate the positions of the various parts of the Refuelling Machine. Used in the safety circuits they are constructed with special materials to withstand ambient temperatures, radiation and to satisfy compatability requirements.



COLVERN Ltd., Spring Gdns., Romford, Essex, England

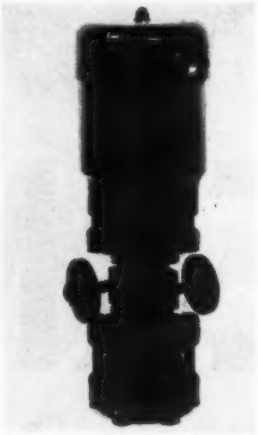
Tel: Romford 62222 PBX
Telegrams and Cables: COLVERN PHONE ROMFORD

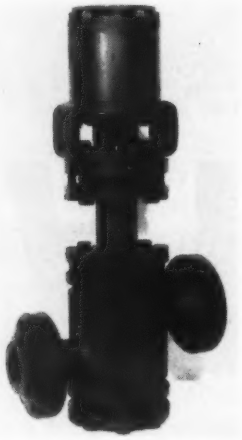
Circle **No 81** on reply card for further details

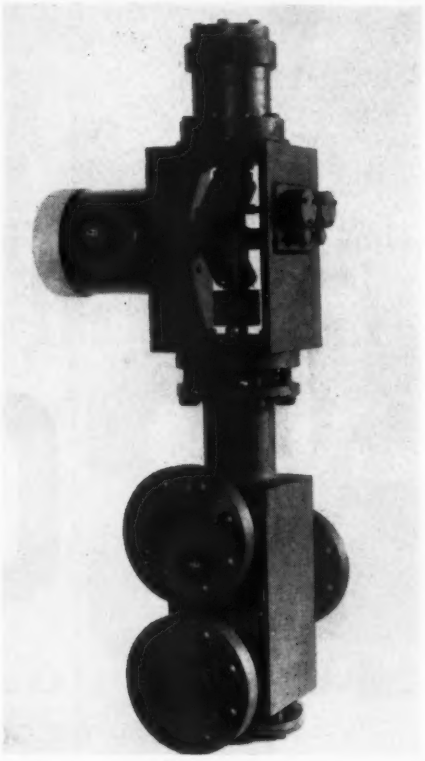
Circle **No 82** on reply card for further details

These illustrations show only three of the Special MAXSEAL Valves supplied to Messrs. John Brown (S.E.N.D.) Limited for use on the Refuelling Machine for the U.K.A.E.A. Advanced Gas Cooled Reactor.

Our entire production is devoted to the design and manufacture of automatic valves for the nuclear, chemical and petroleum industries.







MAXSEAL VALVES LIMITED
WOOD ROAD · KINGSWOOD · BRISTOL

Circle **No 83** on reply card for further details

TEST SIEVES *for*
accurate particle size analysis

Complete range of all sizes of standard test sieves conforming to B.S.410: 1943 and to U.S. standards, A.S.T.M. Ell, readily available. Also special, non-standard test sieves with stainless steel frames and meshes or with nylon meshes.

Frames fitted with precision woven and uniformly taut meshes. One piece frame and spun fillet construction eliminates crevices between frame and mesh where particles could lodge. Made to nest one with another, and to present a perfectly smooth inner surface to the particles of material under test.

PASCALL

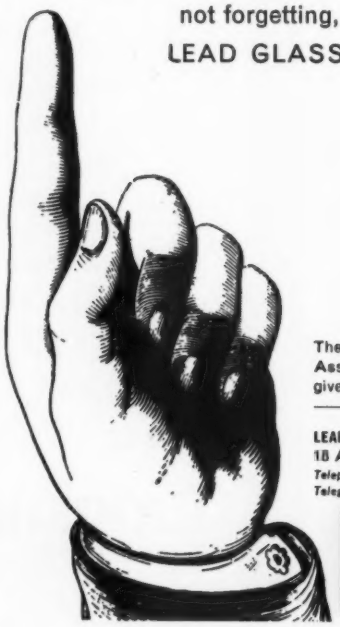
Write or telephone Crawley 25166 for List SV3201

THE PASCALL ENGINEERING CO LTD
GATWICK ROAD · CRAWLEY · SUSSEX

Circle **No 84** on reply card for further details

✳
for protection
against radiation

TRUST **LEAD**
not forgetting,
LEAD GLASS



The technical officers of the Association are always glad to give individual assistance.

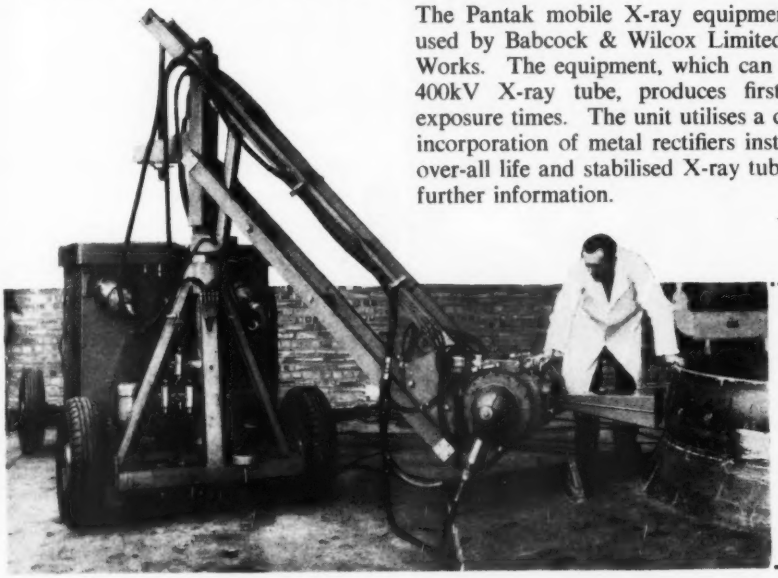
LEAD DEVELOPMENT ASSOCIATION,
18 Adam Street, London, W.C.2
Telephone: WHitehall 4175
Telegrams: Leadevep, Rand, London

LDA6/61

Circle No 85 on reply card for further details

Pantak mobile X-ray equipment for non-destructive examination

The Pantak mobile X-ray equipment illustrated, is one of the five used by Babcock & Wilcox Limited at their Dalmuir and Renfrew Works. The equipment, which can be fitted with either a 300kV or 400kV X-ray tube, produces first-class radiographs using short exposure times. The unit utilises a constant potential circuit, and the incorporation of metal rectifiers instead of valves results in a longer over-all life and stabilised X-ray tube performance. Please write for further information.



MAXIMUM MANOEUVRABILITY

An outstanding feature of the Pantak X-ray equipment is its extreme manoeuvrability. The tube stand, consisting principally of parallel link arms operated by an hydraulic jack, gives a very wide field of movement. The tube stand is mounted on an easily towed truck with pneumatic-tyred wheels and Ackermann steering. The whole unit can easily be operated by one man at ground level.

PANTAK LIMITED

VALE ROAD · WINDSOR · BERKS
Telephone: WINDSOR 3225-6

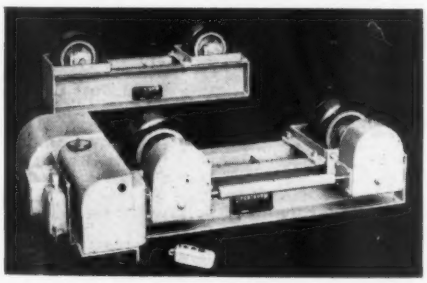
COURTBURN

Equipment For The Welding Trade

Courtburn Rotators are essential for the smooth efficient and economic welding of all cylindrical vessels.

Remote controls with 'stop,' 'forward' and 'reverse' are standard equipment and speed indicators are available.

Rotator sets are made in sizes of 2 tons to 200 tons capacity.



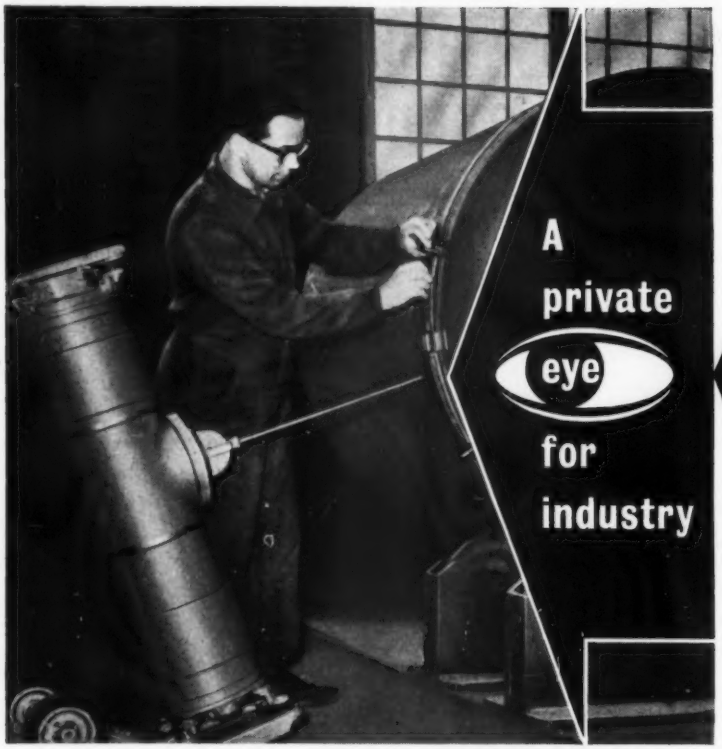
Write for complete catalogue to:

COURTBURN
POSITIONERS LIMITED
STANLEY WORKS, KEMPSTON HARDWICK, BEDFORD
Telephone: Kempston 2341/2

The illustration shows a MODEL VH20 machine for rotating components for continuous circumferential welding by either manual or automatic processes.
The top plate tilts through 135° by turning the hand wheel on the machine, enabling all welds to be laid in the down-hand position.
Selection of the desired welding speeds is by a knob with flexible connection to the variable speed gear box, while push button controls select 'stop,' 'forward' and 'reverse' motions.

IT PAYS TO BUY COURTBURN QUALITY

Circle **No 87** on reply card for further details



Ruggedly built, but still mobile, the Muller Macrotank H is specially developed for on-site radiographic examination in heavy industry, ship and bridge building, nuclear power and refinery construction — wherever complete and accurate weld examination is essential. The small focus (2.3 mm.) of the Macrotank H gives really sharp definition, with a penetration of up to 2¼" of steel with Pb screens in reasonable exposure time. It is low in cost, reliable in use, and backed by full service facilities which may be on contract if desired. We shall be glad to send you full details.

The Macrotank H is a product of C. H. F. Muller, Hamburg.

Sole Distributors in U.K.

RESEARCH AND CONTROL INSTRUMENTS LIMITED

Instrument House, 207, King's Cross Road, London, W.C.1. TERminus 2877

RCL/4176A)

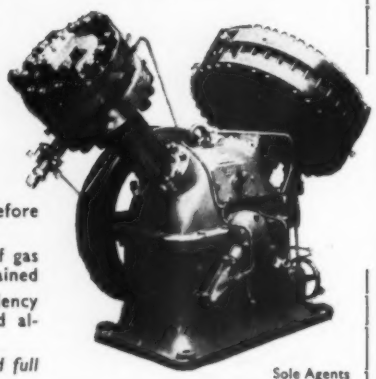
Circle **No 88** on reply card for further details

CORBLIN

DIAPHRAGM COMPRESSORS AND PUMPS

ALL PRESSURES UP TO 30,000 P.S.I.

. . . for pure dangerous or corrosive gases and liquids



- No glands — therefore no losses.
- Absolute purity of gas or liquid always maintained
- Volumetric efficiency remains constant and always at maximum.

Write for Brochure and full details to:

Sole Agents for the United Kingdom

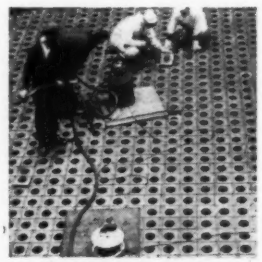
C. T. (LONDON) LTD.

27 Ashley Place, Westminster, London, S.W.1

Telephone: Tate Gallery 8631 (6 lines)

Circle **No 89** on reply card for further details

CLEAN CONDITIONS ARE ESSENTIAL



Simplex model removing dust within No. 1 reactor at Bradwell, on 25th June, 1960.
Photo by kind permission of The Nuclear Power Group, Bradwell and the Central Electricity Generating Board.

New Welbeck Master Cleaners contribute to Britain's great Nuclear Power Programme.

Graphite Stores, Core Construction and Active Areas are maintained under conditions of extreme cleanliness by MASTER CLEANERS because they offer the following essential features:—

- ★ **No Dust Bag**
- ★ **Steel Dust Container with Rubber Base**
- ★ **All Non-Compatible Metals Polythene Coated**
- ★ **Accessories for Special Applications**
- ★ **All Models Light, Portable and Robust**
- ★ **All Standard Voltages and 50v., 110v. for Site Use**

Further information from technical department

By appointment to H.M. The Queen Suppliers of Vacuum Cleaners

NEW WELBECK LTD.

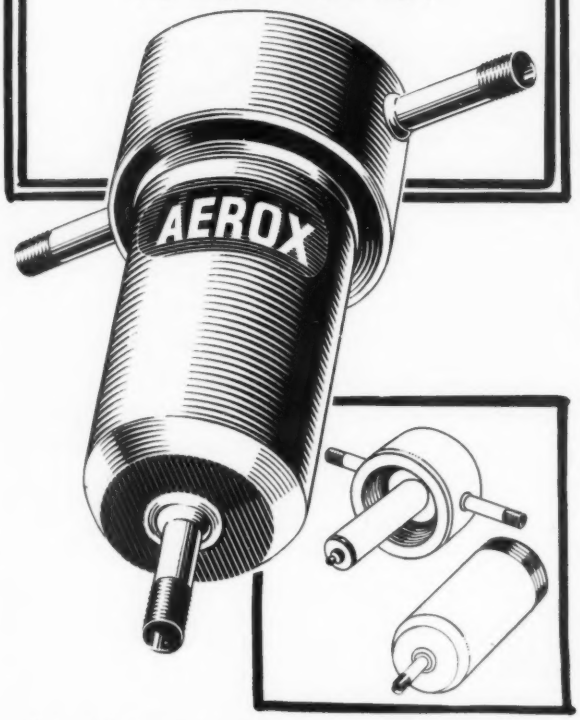
HEAD OFFICE & WORKS: Moulsecoomb Way, Brighton 7, Sussex. Tel.: Brighton 61666 (PBX)

LONDON OFFICE: Southbank House, Black Prince Road, Albert Embankment, S.E.11 Tel.: Reliance 2071

Circle No 90 on reply card for further details

CLEAN AIR INSIDE THE WORKS

(up to 7000 p.s.i.g.)



Pneumatic control and instrumentation depend for their reliability and accuracy on a continuous supply of scrupulously clean air. Aerox Filter Units with Ceramic Elements will give you this.

Oil mist, water, carbon dust, etc., are eliminated without significant pressure drop. Units are available for service at up to 7000 p.s.i.g.; the filter illustrated is one of a consignment for the gas analysis by-pass lines at a nuclear installation.

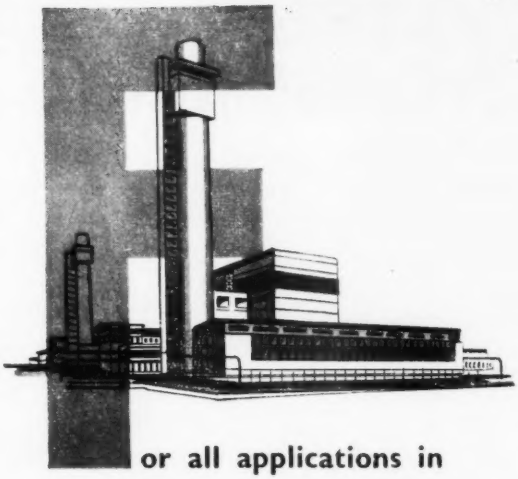
Other units, fitted with Geiger counters inside the element, are being used for analyses of radio-active dust.

AEROX

AEROX LIMITED

Ceramic Works, Hillington, Glasgow SW2
Telephone: Halfway 4615/6.
Engineering Works: Chalford, Stroud, Gloucestershire.
Telephone: Briscombe 3085/6.

Circle No 91 on reply card for further details



or all applications in Nuclear Power plants . . . . . continue to fit

FREMO STAINLESS STEEL

bolts, nuts, screws and other fasteners with corrosion, contamination and heat resistant properties.

FREMO
TRADE MARK

FREDERICK MOUNTFORD (BIRMINGHAM) LIMITED

Fremo Works, Moseley St., Birmingham, 5
Tel. MIDland 7984 PBX
Grams 'FREMO' Birmingham

CLASSIFIED ADVERTISEMENTS

DISPLAY ANNOUNCEMENT RATES:— 1 insertion 50/- per single col. inch
6 insertions 47/6 per single col. inch
12 insertions 45/- per single col. inch

LINEAGE ANNOUNCEMENT RATES:— 5/- per line, 5% discount for 6 insertions, 10% discount 12 insertions

BOX Nos.:— 1/- extra will be charged

COPY DATE:— Advertisements for June issue to be received not later than May 8th.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

require

ASSISTANT EXPERIMENTAL OFFICERS

to join teams engaged on the following research:—

(A) Physics studies of experimental fast reactors.

(B) Physics of fission using a research reactor and large scintillators.

Applicants should have a pass degree, H.N.C. or equivalent qualification. Previous experience in the above fields is not necessary but, experience in electronics, vacuum techniques, nuclear counting methods or general experimental physics would be an advantage.

SALARY:— £640 (at age 21)—£860 (at age 26 or over)—£1,055 p.a.
Superannuation scheme. Financial assistance towards house purchase will be available for married officers living beyond daily travelling distance.

Please write for application form to the Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks., quoting ref. 2953/202.

Hawker Siddeley Aviation
LIMITED

GUIDED WEAPONS

A. V. ROE & CO. LIMITED
WEAPONS RESEARCH DIVISION
WOODFORD, CHESHIRE

AEROPHYSICS GROUP

The above Group which is engaged in the study of the aerodynamic heating of high speed missiles has vacancies in its HEAT TRANSFER LABORATORY for the following graduate level personnel.

1. A SECTION LEADER,

of Senior Staff status, to lead a small team and be responsible for the planning and direction of the experimental work of the laboratory.

2. A TECHNICIAN

to assist in the work of the laboratory.

The work consists of the study of basic heat transfer processes and the evaluation of new cooling and insulation systems in a well equipped laboratory. The experimental investigation of the aerodynamic heating of flight test vehicles is also involved.
Some experience in temperature measurement techniques and general laboratory practice would be an advantage.
The Division is situated on an airfield in rural Cheshire close to housing and shops and on main bus routes. A Superannuation Scheme is in operation and there are excellent Canteen and transport facilities.

Apply:—
The Personnel Manager,
A. V. ROE & CO. LIMITED,
Greengate, Middleton, Manchester,
quoting Ref. Aero/R. 159/N.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY POSTGRADUATE COURSE IN NUCLEAR POWER

A full-time postgraduate course in nuclear power is held each year. This course is conducted from the engineering point of view and is intended primarily for graduate engineers and applied scientists wishing to pursue a career in the design, development and construction of nuclear power stations. A special feature of the course is the inclusion of a design study of a complete nuclear power project. Experimental work includes the use of a natural uranium-graphite exponential assembly.

Further information on application to the REGISTRAR, IMPERIAL COLLEGE, LONDON, S.W.7.

COURSES

THE UNIVERSITY OF MANCHESTER POSTGRADUATE COURSE AND RESEARCH IN NUCLEAR ENGINEERING

The postgraduate course, which is of one year's duration, is intended for graduate engineers, physicists, or metallurgists who wish to specialise in the field of Nuclear Engineering. Students attend a course of lectures on the fundamentals of the subject, supplemented by selected topics at a more advanced level, and also undertake an experimental project. The Diploma for Advanced Studies in Science is awarded to candidates who successfully complete the course. The Department of Scientific and Industrial Research has accepted the Postgraduate Course in Nuclear Engineering as suitable for the tenure of its Advanced Course Studentships.

The Department is engaged in research on heat transfer, reactor control and experimental reactor physics. Applications are invited for facilities to undertake research in these topics.

All applications and enquiries should be addressed to Professor W. B. Hall, Nuclear Engineering Laboratories, The University, Manchester, 13.

COURSES (contd.)

TRAIN FOR A CAREER IN TEACHING ENGINEERING SUBJECTS

Persons aged between about 25 and about 45, with good industrial experience, are invited to apply for training as FULL-TIME TEACHERS OF ENGINEERING SUBJECTS IN TECHNICAL COLLEGES AND SCHOOLS.

EXCELLENT CAREER PROSPECTS

NEXT COURSE: SEPTEMBER, 1961, TO JUNE, 1962.

Applicants should hold suitable qualifications, e.g., a university degree, associate or graduate membership of a professional institution, Higher National Certificate, Final or Full Technological Certificate of the City and Guilds of London Institute.

NO TUITION FEES

PERSONAL, MAINTENANCE, DEPENDANTS' AND TRAVELLING GRANTS PAYABLE.

For details write immediately, quoting S/31b to either:

The Director, Bolton Training College, Manchester Road, Bolton.
The Director, Huddersfield Training College, Holly Bank Road, Lindley, Huddersfield.
The Principal, Garnett College, 83 New Kent Road, London, S.E.1.
The Director of Education (Wolverhampton Training College), Education Offices, North Street, Wolverhampton.

SUPPLY & SERVICE

ALUMINIUM DESIGN
and fabrication service available for all types welded and other light alloy structures and components
ALPHAMIN LTD.
4 Dunston Street, Kingsland Road, London, E.8. Tel.: CLIssold 4161

FOR ALL METAL FINISHES
Electro Plating in Rhodium, Gold, Silver, Cadmium, Chromium, Nickel, Copper, Tin, Zinc, Lead, etc. Enamelling, Lacquering, Shot-Blasting, etc.
A.I.D., A.R.B., D.I.A.R.M. Approved.
HARRIS PLATING WORKS LTD.
18 New Wharf Road, London, N.1. **TERminus 7263 (5 lines)**

PROTOTYPES
Design and construction of Special Machinery
•
RESEARCH ENGINEERS LTD.
Northampton Grove, Canonbury, London, N.1
CANonbury 4244
Telegraphic Address:—
Wilmaket, London, N.1

A. W. ELLIOTT (Steeplejacks) & Co. Ltd.
34 Nuthall Road, Nottingham
Nottingham 77195
Lightning Conductor Specialists
Chimney Maintenance, Church Restoration, Industrial Painting, Decorating.

R. & J. PARK LTD
Dominion Works, Chiswick England
•
Export packers, shippers and forwarding agents. Specialists in packing heavy machinery

C. W. GARRETT & SON LTD.,
for
ALL DRAWING OFFICE SERVICES, PROCESSES, MATERIALS AND EQUIPMENT
•
WINDMILL ROAD, BRENTFORD MIDDLESEX
Telephone: ISLeworth 4433 (4 lines)

Higher Tensile Steel Chain Slings and special Lifting Appliances of every description D.G.I. approved
TOM SMITH & CLARKE LTD.,
Chain Manufacturers,
Port Tennant, Swansea
Telephone No. 53106 (4 lines)

NON-DESTRUCTIVE TESTING LABORATORIES
Vacuum, X-Ray, Gamma-Ray and other forms of Non-Destructive Testing.
•
INDUSTRIAL RADIOGRAPHY (N.D.T.) LTD.,
Cricket Inn Rd., Maltravers Rd., Sheffield, 2.
Telephone:—Sheffield 26630—21200

GILSTON ENGINEERING CO.
Specialists in all applications of STAINLESS STEEL
Fabrications *Press Tools*
Precision and Production Engineers
Lea Road, Waltham Abbey, Essex
Telephone: Waltham Cross 23871

AT YOUR SERVICE
when you need an expert

★ Please send for our comprehensive leaflet, which gives technical data and details of applications quoting ref. NP2

HUNT HEAT TRANSFER EQUIPMENT
HUNT HEAT EXCHANGERS LTD.
MIDDLETON MANCHESTER
London Office: Temple Chambers, Temple Avenue, E.C.4.
Telephone: Ludgate Circus 7796/7
HH 2

ADVERTISERS IN THIS ISSUE

Aerox Ltd 123
Appleby and Ireland Ltd 112
Armstrong Whitworth Aircraft Ltd, Sir W. G. 43
Atlas Steel Foundry and Engineering Co. Ltd, The 114
Atomics International 13

Bailey & Co. Ltd, Sir W. H. 118
British Acheson Electrodes Ltd 99
British Ermeto Corporation Ltd 27
British Lead Mills Ltd 113
Brown (S.E.N.D.) Ltd, John 21
Burgess Products Co. Ltd 111
Butterfield (Engineers) Ltd, W. P. 12

Carlisle & Co. Ltd, C. G. 118
Carter & Viner 115
Castrol Industrial Ltd 52
Central Electricity Generating Board, The 95
Classified Advertisements 124
Colvern Ltd 119
Consett Iron Co. Ltd 19
Courtburn Positioners Ltd 121
Cox and Danks Ltd 117
CREI (London) 15
CSF 31
C. T. London Ltd 122

Delaney Gallay Ltd 115
de Havilland Aircraft Co. Ltd, The 7

Electronic Switchgear (London) Ltd 20
Elliott Nucleonics Ltd 101
E.M.I. Electronics Ltd 17

Fielding & Platt Ltd 14
Flexello Castors & Wheels Ltd 108
Flexibox Ltd 42
Foster Wheeler Ltd 44
Frazar & Hansen Ltd 116
General Electric Co. Ltd, The 116, 128
Gentilly, Fonderie de 110

Harlow Printing Works (Northern) Ltd 117
Hawker Siddeley Nuclear Power Co. Ltd 38
Henderson & Keay Ltd 23
Holland Engineering Co. Ltd, The B. A. 110
Howden and Co. Ltd, James 2
Hunt Heat Exchangers Ltd 125

Imperial Aluminium Co. Ltd 103
Imperial Chemical Industries Ltd 41
Industries Atomiques 112
Isopad Ltd 18
I.V. Pressure Controllers Ltd 10

Keith Blackman Ltd 11
Kennedy & Co. Ltd, Allan 39
Kidde Co. Ltd, The Walter 108
King Aircraft Corp. (KAC) Ltd 118

Lead Development Association 120
Lincoln Electric Co. Ltd 8
Lockheed Precision Products Ltd 30
Lyons Ltd, Claude 114

Magnetic Valve Co. Ltd, The 16
Marshall of Cambridge Electronics Ltd 104
Marston Excelsior Ltd 45
Maxseal Valves Ltd 120
Mollart Engineering Co. Ltd 46
Mountford (Birmingham) Ltd, Frederick 123
Mullard Ltd, (X-Ray Div.) 97

New Welbeck Ltd 122
Newall and Co. Ltd, A. P. 40
Newalls Insulation Co. Ltd 24
N. G. N. Electrical Ltd 104
Nuclear Equipment Ltd 4, 5

Osborn and Co. Ltd, Samuel 29

Pantak Ltd 121
Pascall Engineering Co. Ltd, The 120
Permali Ltd 26
Plannair Ltd 47
Plessey Nucleonics Ltd 32
Power Auxiliaries Ltd 35
Premier Cooler & Engineering Co. Ltd, The 117
Pyrotenax Ltd 28

Research and Control Instruments Ltd 122
Rio Tinto Management Services (U.K.) Ltd 37
Richardsons, Westgarth and Co. Ltd 34
Rocol Ltd 36
Rotork Engineering Co. Ltd 106

Serck Radiators Ltd 6
Shell Cutting Oils 48
Simplifix Couplings Ltd 106
Stainless Steel Profile Cutters Ltd 126
Stewarts and Lloyds Ltd 127
Stillite Products Ltd 25
Sulzer Bros. (London) Ltd 22

Taylor Rustless Fittings Co. Ltd, The 107
Teddington Aircraft Controls Ltd 33

Unbrako Socket Screw Co. Ltd 9

Vandyke Engineering Ltd 50
Vokes Ltd 105
Vokes Genspring Ltd 109

STAINLESS STEEL FLANGES

Specialists in the manufacture of —

★ FLANGES MACHINED TO B.S. TABLES OR TO SPECIAL SIZES

★ PROFILES CUT FROM PLATE TO ANY THICKNESS OR SIZE

From approved grades of stainless steel

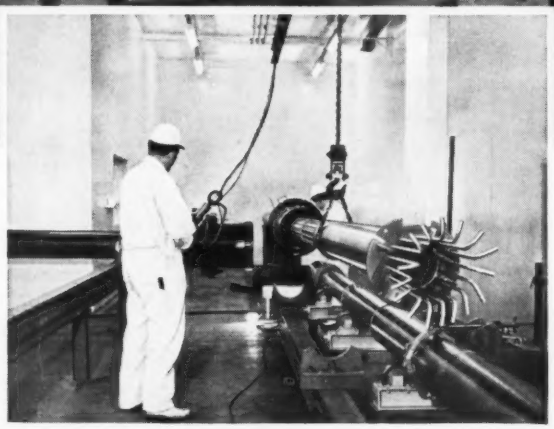
KEEN PRICES—PROMPT DELIVERIES

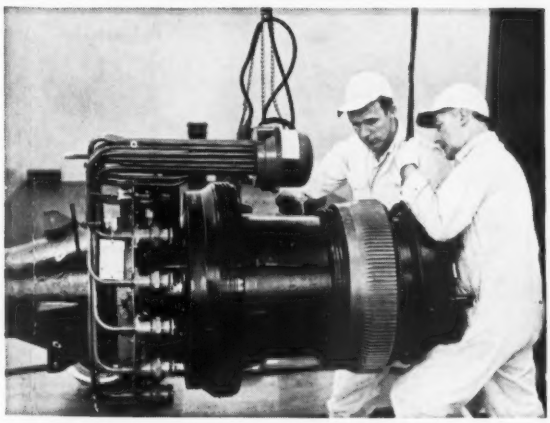
Let us quote for your requirements.

STAINLESS STEEL PROFILE CUTTERS LTD.

Dept. N.P. Farfac Works, King's Grove, MAIDENHEAD, Berkshire

'phone 1522/23.





S&L Pipework for Hunterston

S&L, backed by a century of experience in the manipulation of pipework, has been associated for many years with power plant projects throughout the world.

For Hunterston nuclear power station S&L are supplying the control rod standpipes. The illustrations ~~show some of the~~ standpipes in the Company's new clean conditions plant at their Tollcross Works in Scotland.

Stewarts and Lloyds' Pipework Engineering Division has been awarded other main contracts for Hunterston including:

Integral pipework for steam raising units; also pipework for main steam, high and low pressure feed, auxiliary CO_2 and circulating water mains.

PED

PIPEWORK ENGINEERING DIVISION

STEWARTS AND LLOYDS LIMITED

Tubemakers for a Century

GLASGOW · BIRMINGHAM · LONDON

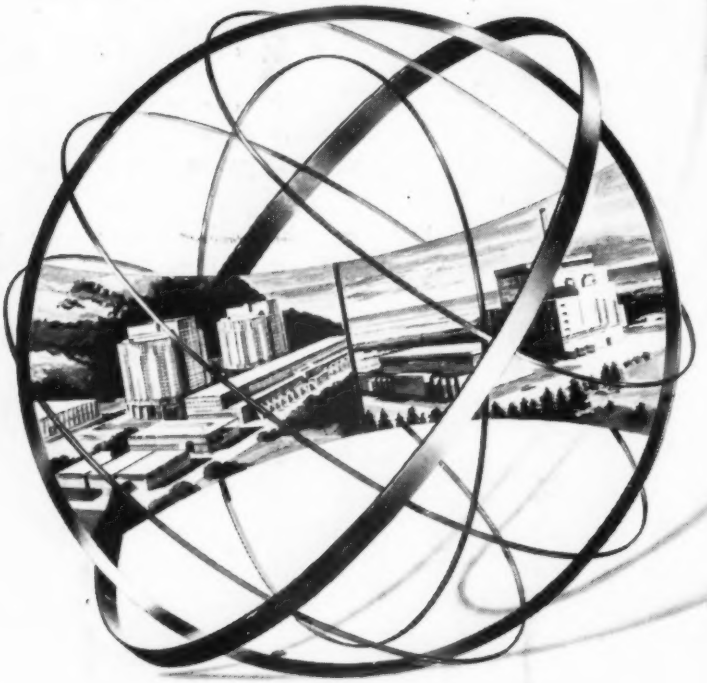
Circle **No 206** on reply card for further details

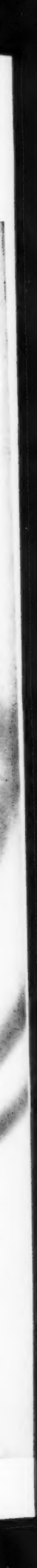
G.E.C.

on both sides of the world

ATOMIC ENERGY GROUP

Seventy miles from Tokyo, at Tokai-Mura, the British General Electric Co. of Japan Ltd. is building Japan's first full-scale earthquake-proof nuclear power station to designs produced by The General Electric Company Limited of England and Simon-Carves Ltd. When completed in 1965, this will represent a triumph for nuclear engineering. On the opposite side of the world, at Hunterston, G.E.C. and Simon-Carves are building one of the world's largest nuclear power stations to provide power for the South of Scotland Electricity Board. The combination of G.E.C. and Simon-Carves Limited makes available prodigious resources for atomic power development. As one of the largest electrical and mechanical engineering Companies in the world, G.E.C. itself employs over 70,000 people. Simon-Carves Limited is one of the leading British specialists in large steam-raising plant, coal cleaning and carbonising plant, and in chemical and civil engineering. The Group is able to design, build and install nuclear power stations anywhere in the world, to suit local conditions.



HEADQUARTERS: THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND, ERITH KENT

396